

HUMAN REACTIONS IN A MAZE OF FIXED
ORIENTATION

BY
NELLIE LOUISE PERKINS

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE
UNIVERSITY OF MICHIGAN

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From the Psychological Laboratory of the University of Michigan

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I. INTRODUCTION

A. Review of the literature

Interest in the problems of motor learning has produced many experimental studies. In many of these, mastering a maze has been the problem set. Animal subjects have been very popular in these investigations but little has been done in the analysis of human reactions in the maze. In the last decade, probably because of the growing interest in the psychological processes involved, parts of the earlier animal experiments have been repeated with humans. The history of the development of the investigations is similar to that in the animal field in that the first studies were concerned with whether or not the subjects could learn the problem set. This was followed almost immediately by an interest in the comparative study of different groups of subjects.

One of the first serious studies recorded in which humans were used was made by Carr and Hicks (4) in 1912. A simple maze, made of posts and guide wires between which the blind-folded subjects walked, constituted the apparatus for the human subjects, 4 men and 5 children, eight to thirteen years of age. A similar set-up was repeated in the animal maze for a group of rats. Records of time, distance, trials and errors were kept and a comparison of the results for the three groups of subjects was made on the basis of the different criteria of learning and the degrees of intelligence of the three groups of subjects as indicated by the total reactions. The learning curves showed a definite inverse relation to hold between the degrees of intelligence and the amount of surplus values eliminated, the ratios being approximately 1:2:3. It was found that the rapidity of elimination of gross values varied in different stages of learning for each of the groups indicating a real difference between them; for instance, all three had a rapid initial spurt but the children made the most

rapid initial descent which terminated in the third to the fourth trial and was followed by practically no gain for several trials suggesting a plateau, whereas the adults' initial spurt was less rapid and did not end until the ninth or tenth trial with no suggestion of a plateau following. The rats occupied an intermediate position. All three groups of subjects eliminated distance more than errors and about to the same degree but they differed in the period at which this occurred, the gain of elimination of distance over elimination of error occurring earliest in adults, next in children and last in rats. The rats ran the maze more rapidly and made the greatest gain in speed with successive runs while the humans eliminated errors more rapidly in time. On the whole, the animals were found to be more variable than humans. Aside from these brief comparisons, the main discussion is grouped about the relative value of the various methods of recording learning, with the conclusion that, for the maze, the two which best serve as direct indices of intelligence, are (1) the reciprocals of the surplus values of time and error and (2) rapidity with which distance is eliminated in relation to errors, and further, that these are valid only when limited to gross comparisons.

Perrin (14) made the second experiment in which humans were used. The introspective approach was made the basis of the study in an attempt to get at the imagery and the subjects' ideas of their methods of attack with the hope of getting at special aspects of the learning process. There were four experiments. In all but one, stylus mazes were used. In the second experiment the maze was made of wire netting stretched between stakes; the pathways were wide enough for the subjects (blind-folded) to walk through in an upright position. Only adults were used. In the first two experiments, the subjects were permitted to use any method that would not interfere with the instructions given, the object of the study being to get at the objective behavior and the nature of the learning process. In the last two experiments, the subjects were instructed to assume certain attitudes. In brief, the analyses indicated that the immediate reaction upon the maze was largely perceptual in its nature. The more complex mazes elicited higher mental activi-

ties but the rational processes reported were found to be unsystematic and futile. The experimenter suggests that the meager attempts at reasoning might be explained by the fact that the learners had no past experience to apply to the situations. In discussing the simple functions involved in learning, the various types of imagery were analyzed and the conclusion drawn that each individual employed his peculiar image equipment for all mazes. It is further concluded that pure trial and error and pure reasoning or even ideational learning were equally inadequate terms to characterize the learning method. The report is concluded with a discussion of the learning curves which resembled those reported in earlier animal work, in that there were steeples and a rapid initial descent.

The next group of experiments may be roughly characterized as criticisms of learning curves and methods of recording. The one experiment in which humans were used as subjects was that of Perrin and Gould (15). A stylus maze was introduced. Ten children (average age 11.5 years) and fourteen adults acted as subjects. While problems characteristic of the earlier experiments such as memory, attitude, and relative intelligence of the two groups of subjects were noted, the main interest was centered about a discussion of the various methods of evaluating learning or the relative value of different records and the difference between the two groups of subjects in terms of number of trials, total time and errors and distance. The authors conclude that the maze offers an opportunity for a comparison of learning curves but places a premium upon purely chance discovery. They recommend the standardization of technique and a more detailed study of the significance of a learning curve with the suggestion that a combination time and error curve offers the best method of quantitative records.

Special problems such as transfer of training, influence of mechanical guidance and habit interference characterize the third period. In 1917 Webb (26) reported on a study of transfer of training using humans and rats as subjects in a series of mazes. The experimental conditions for the two groups were kept as nearly comparable as possible. The author found practically

no cases of habit interference where total time, errors, and trials were the criteria considered, a relation that held even where a definite attempt was made to produce negative transfer. The factors most influencing the amount of transfer, were found to be (1) the nature of the first and second habits, (2) the degree of similarity between the mazes and (3) the direction of transfer. It was also found that the second habit started approximately at the level attained at the fifth trial of the first habit which the author interpreted to mean that the transfer effect had its locus in the first five trials of the second habit. The loss and conditions of transfer for the two groups of subjects appeared to be essentially the same. No correlation was found between the learning and re-learning for either group of subjects although the humans showed a slightly higher retention of the first habit learned.

A second study of habit interference was made by Hunter (9) in 1922. A simple pencil maze with alternating right-left turns was used for the first habit. The maze was then turned 180° with reference to the subject for the second habit. It was found that one simple habit might seriously interfere with the formation of a second habit but the formation of the second habit did not interfere with the retention of the first. When the interference was expressed in the terms of a comparison of the first part of the curves for the two habits, interference might or might not reveal itself during the first six-tenths of the learning. (The first tenth of Habit 2 required even less time than the last tenth of Habit 1.) Rats were also used in animal mazes for this experiment and comparisons of the two groups were made but the results are not included in this summary because they have no bearing on our problem.

In 1923 another investigator, Koch (12) worked on the effect upon learning of mechanical prevention of errors, using humans for subjects and an especially constructed stylus maze in which blinds could be closed at will. Errors were prevented in certain periods of learning by blocking the entrances to blind alleys. Various amounts of guidance were tried and control was concentrated within the first twelve trials to determine the effect on

retention. The subjects were also retested in forty-eight hours. It was found that with the human subjects, the efficacy of the control tended to vary directly as the distance (within limits) of the series of the guided runs with the initial trial and varied with the period of learning at which the guidance was interpolated. The relation between the amount and the efficacy of control was not constant but seemed to vary with position. In the early runs, the guided groups made fewer errors than the unguided groups but just as soon as familiarity with the pathway was attained (the turns no longer acted as barriers) there was a temporary increase in the retracing. The author regards this as the result of conflict and confusion due to the alteration of cues upon which the subject had come to depend. Guidance also introduced a certain general "set" which influenced learning but the author does not discuss this in detail. It is simply suggested as one of the factors to be reckoned with. Where the control was introduced with the first six trials it aided retention but the influence was unfavorable, if introduced after the sixteenth trial. Animals were also used in this study, but the results do not concern us.

Warden (25) reports on the effect of various modes of attack on learning a stylus maze. The subjects were allowed to choose their own method and the results were then divided according to the method used. There were three types (1) the "word reaction"—where the subjects associated verbal symbols with the direction and order of the turns and attempted to memorize them (2) "visual imagery"—where there was a more or less complete visual image of the maze pattern in which the various points of decisions were visually associated, and (3) "motor method" where kinaesthetic cues rather than either of the first two, determined the selection. Only 30 per cent of the subjects fell into this group while 40 per cent were found to depend primarily upon explicit or implicit verbal cues. Analysis of the results for the three types of response indicated that the verbal was the most effective, in that, it required on the average less than one-fourth as many trials for complete mastery as the motor group, and one-half as many as the visual.

The discussion in more recent investigations tends to be centered about the theories of motor learning and the experiments have been planned to test the various factors individually in order to determine their relative influence on learning. The effect of frequency and recency has come in for considerable discussion in the animal field, with the tendency to carry over the conclusions into human learning. Peterson (18) however, designed two special mazes and a technique for rats where frequency and recency were negative factors. The probable number of errors for each blind based on chance responses was worked out mathematically and it was found that under the condition of this experiment the correlation between the actual and expected errors in all parts of the maze was high. The errors were eliminated in the backward direction. It was found that agreement with recency had no relation to the rightness of response in case of frequency. Agreement with the law of chance was somewhat more likely to occur in the wrong than in the right responses, whereas disagreement was more likely to be found in the right rather than in the wrong responses. Peterson concludes that frequency and recency are not real determining conditions of learning.

In a second experiment with a "mental maze," succession of orally given choices, Peterson (20) again used similar technique. In this experiment, backward elimination of errors was found to be the rule and retracings upon emerging from a blind were eliminated earlier than blind alley entrances. Again the experimental results compared favorably with expectations based on the law of probability and the mathematical determination of the learning coefficient which he defined as ratio of the expected number of runs past a blind in the forward direction to the expected number of runs into it from either direction.

Further experiments with the effect of primacy and recency factors are reported by Warden (24) who also designed a stylus maze, the special features being: (1) a series of equally similar unit spacial situations except for the fact that half were right and half were left. (2) The essential problem at each of the ten critical points was to choose between a right and left turn.

(3) Movements of traversing a cul-de-sac after a wrong choice had been made was precisely the same as the number along the true path which would have been made in avoiding it except that it extended in the opposite direction. (4) Each cul-de-sac was preceded by a one inch groove running in the forward direction so that the immediate antecedent movement in approaching a cul-de-sac was the same throughout the maze. (5) The only pattern variation was that the right and left turns were not arranged in a simple alternating series. The author concludes that other things being equal the blinds near both ends are entered less often and eliminated much earlier than those lying in the middle indicating a primacy-recency order of blind elimination instead of a regressive order. The second maze learned was a lateral reversal of the first. With this single change there was a decided difference in the difficulty. A second experiment was tried in which the opposite hand was used in tracing with the result that it was found that the left hand tended to make errors more frequently and persistently in the right lateral half of the maze in both patterns while the right hand tended to make errors more frequently and persistently in the left half and in approximately the same proportion. In other words, the blinds on the same side of the pattern as the hand were consistently favored while those on the opposite side were at a disadvantage.

Hunter (10) made a correlation study of rats and humans and also compared the reactions of humans in a maze and in an intelligence test (Otis). Two mazes were used for humans and three for rats. The results showed that the mazes belonged to markedly different grades of difficulty. With the humans, during the first half of the learning, the amount of improvement seemed to be inversely related to the difficulty of the maze. Comparing the various methods of recording the author concludes that total time is a better indication of ability than total trials or total errors. He found that the slope of the curve representative of the learning process was related to intelligence and further that the total time of learning when correlated with the Otis scores indicated that common factors were at work. In comparing the mazes and intelligence it was found that the more

complex habits (the more difficult mazes) offered the lower correlations. The author felt that the simpler mazes gave less opportunity for chance to effect the records and a greater amount of control over the subjects so that the data with them would be more dependable. In comparing the records for the more complex mazes very little difference was found. In comparing the two groups of subjects even in the simplest habit, rats showed a greater instability of response than the humans.

A comparison of individual differences in ability and the factor of chance in the learning of a stylus maze was made by Heron (6). Five pencil mazes were used. These were learned first in serial order and then the first, second, and fourth were repeated. Records of total time, number of errors, and number of trials were kept and correlations made to bring out comparisons between mazes and between the original and second learning. It was found that chance and individual ability were both influential in the production of scores in maze learning and further that the two factors varied with the pattern of the maze in the respective parts which they played in the determination of the scores. In no case was individual ability found to be more influential than chance but there were several instances in which chance was very markedly more influential than individual ability. The relative influence of differences in individual ability and chance upon the group averages of scores in maze learning was also investigated. Two methods of attack were used. The total group of 90 subjects was divided into smaller groups on the basis of the subjects' efficiency in the fourth maze and the average scores of such groups was found for the five mazes. In the second method the total group of 90 subjects was divided into smaller groups by chance selection and the averages of such groups were found for each maze. The results by the first method showed that (1) when the total of 90 subjects was divided into groups of 45 each, the two groups so attained were of unequal ability and (2) the average difference in maze ability of the groups appeared to be due, for the most part, to a limited number of subjects within each group. These subjects were found to be those who remained consistently in one or the other of the

halves in all five mazes. Results for the second method showed that within the limitations of the experiment it was impossible to find groups which could be said definitely to be of the same ability. However, when the large group was divided into halves, the two groups thus attained were much more nearly the same ability than when the same division was made by the first method. Again this difference in averages of groups was found to be due at least to some extent to the same cases which were responsible for it when the groups were divided by the first method.

The most recent experiment reported was made by Hunter and Randolph (11) and is a continuation of an earlier study made in an attempt to determine the reliability of the maze for testing motor learning.

Three experiments were carried on with fairly large groups of human subjects (30 in each of the first and second experiments and 40 in the third). A time record was used and the results correlated in a way to cover the various factors supposedly influencing the learning process. The results are summarized as follows:

No maze, either for rats or humans, is analyzed sufficiently to justify the unqualified acceptance of data gathered from it with reference to the determination of individual and group differences in learning. Habit-formation does take place in the maze, and most subjects can be trained to the point of mastery; but a comparison of subjects upon the basis of the data gathered on the learning process itself is of very uncertain value. At the present time the T-shaped maze seems the most dependable for rats. With humans, Heron's maze 4 and Hunter's simple A-maze are suggested for use.

Although the rat in the maze (and undoubtedly in problem boxes and discrimination boxes also) apparently affords a very unsatisfactory situation for studying the *course* of the learning process and the modification of that course by various factors, the same criticism is not applicable after the completion of the learning. Once the subject becomes automatic in its response, the experimenter may introduce various extraneous factors into the situation and study their effects through the consequent *presence or absence* of the automatism. So much can certainly be done with scientific safety. Where the distinc-

tion of "more or less" loss of perfection is utilized, we are again upon very uncertain ground, inasmuch as no specific study has been made of the reliability of degrees of difference under these conditions.

Within the last few years there has been an increasing interest in the correlation between results in a maze and intelligence ratings. Three of the studies (Warden (25), Hunter, (10), Heron (6)) referred to here had sections on these relations but they were not included in the brief reviews because they represent departures outside of the province of our study.

B. Statement of the problem

With two exceptions (Carr and Hicks (4), and Perrin (14)) every maze used with human subjects has been the stylus type. This, in itself, presents a problem which has not been analyzed, namely, the factor of fixed orientation. Although the pattern of the maze has been mentioned as a possible explanation of certain reactions in the maze, no investigation of this factor has been referred to in any of the literature. The purpose of this study is to investigate exhaustively the process of learning in a maze with fixed orientation in order to determine whether any conclusions could be drawn in regard to the method of attack, the order of dropping errors, and the psychological processes entering into the learning.

The experiment was divided into two parts—first, learning a maze sufficiently difficult to constitute a real problem for adult subjects, giving an opportunity for concentrated effort over a comparatively long period, and second, modification of the original experience to determine the behavior characteristic of the reactions to similar situations in which there are certain fundamental changes. It was hoped that an analysis of adaptation to changes might help explain learning in the original situation.

II. APPARATUS AND METHOD OF PROCEDURE

A. Apparatus

Special labyrinths were designed in order to eliminate if possible various objectionable features in other mazes, such as

unique turns, regular swings which could set up rhythms, and various landmarks which might play a part in the learning and yet be immeasurable. It had also been impossible to find any maze that could be easily adapted to meet the requirements of the second series of experiments where modification of mazes was necessary to test out methods of adapting to changes.

The labyrinths were drawn on paper, the lines being about $\frac{1}{32}$ inch in width and uniformly black. The paths were $\frac{3}{4}$ inch wide and varied in length, direction and number of turns. For each segment of the correct path, there was a blind; thus points of decision always involved one of two possible turns and never one of three or four, as is of more or less frequent occurrence in many of the mazes used in other experiments. In planning the paths, the intention was to avoid regular and long sweeps so that rhythms on this score would not be set up. Blinds were designed to vary as follows:

Type I—Continuation of the true path

Type II—Offshoots from the true path ("Go-bye")

Type III—Abrupt ending and splitting of the true path (T's)

All turns were right angles and landmarks of every kind were avoided so far as possible. (It will be seen by the results that we were not successful in avoiding conditions which would set up rhythms, and all landmarks were not ruled out.)

For the experiment, the maze was placed on a table with a glass top under which were twelve electric lights. Dark curtains fell from the table top to the floor and cut off all light except that under the maze. This threw the lines out in strong relief and made the paths very distinct. A piece of plate glass was placed over the maze in order that the paths would not become soiled or marked by the paste-board tracing tube. The table was 4 feet high and 3 feet square. As a maze covered the table top, it was necessary to elevate the subject in order that he might reach all parts of the field. For this reason he was seated on a high stool.

The tracing tube consisted of a black paste-board tube 1 inch in diameter and 10 inches long. This tube was thrust through

the center of a 12-inch black paste-board square which was held in position by a rubber band two inches from the top of the tube. The subject held the tube below the square shield, the lower end of the tube or a projection from it resting on the glass cover over the maze. In looking through the tube all the field, except the small range allowed by the circular opening, was cut off and the subject could see none of the field except the part of the path which lay directly at the bottom of the tube. With the paths three-fourths of an inch in width and the tube one inch in diameter, both sides of the path could be kept in sight and all openings or breaks could be seen easily. This arrangement allowed for visual cues as well as kinesthetic, a thing which is not possible in the pencil mazes used in other experiments with humans. On the other hand, this type of maze is not comparable with those used for animals, where the animal is put into the maze and runs it with his whole body. To make the experience in both the human and animal fields absolutely comparable, the mazes used should be the same, but inasmuch as modification for humans of mazes of the type used for animals would be expensive in construction and require more space than is usually to be had, all of which makes it impractical, we are forced to design mazes which are more or less the same in principle, even though they are physically incomparable to those used for animals. The mazes used in the experiments with animals and with humans differ essentially in absolute orientation.

B. Method of procedure

The subject sat at the table with the maze placed directly in front of him. After placing the tracing tube in position at the starting point *A*, the lights were switched on and the subject proceeded to trace the paths. He was told nothing about the problem beyond the fact that it was an experiment in learning,—an attempt to study how humans learned a new problem. Hoping to get original methods of approach, we did not offer any suggestions or help, beyond the statement that he was to find the shortest possible path from the starting point, *A*, to the point of

exit, *B*, the position of which was unknown to him until after the first run, when he discovered it for himself. He was left to his own initiative. There were no directions, except that the tracing tube was not to be lifted from the maze and the subject was to do no exploring except through the tube, which was to be kept on the paths. This meant of course that no lines were to be crossed. The rate of traversing the paths was also left to the subject. Nothing was said about it and each one chose his own rate. He was told that he might think out loud, provided this did not disturb him, but the operator made no comments and simply recorded all remarks made by the subject, as well as the paths followed, indicating at what points remarks were made.

All mazes, that is, the basal maze and its two modifications, were learned at one sitting, which meant concentrated work over a relatively long period. The time ranged from one and one-half to four hours, depending upon the subject, but most subjects required the same amount of time, namely, about three hours. Except in one experiment, each subject learned but one set of mazes and all of the discussion is based upon the original learning of the first maze and its two modifications.

The trials were made in succession with interruptions for drawings and introspections between every three trials, a trial consisting of a run from *A* to *B*. As soon as *B* was reached, the operator replaced the tracing tube at *A* and another trial was begun. At the end of the third trial, the subject was asked to go into the next room where he was to draw as well as he could what he had been through. If he could not give the exact turns or if any parts were hazy, he was to indicate the general direction of the paths. He was urged to make an attempt to reproduce as nearly as possible, in graphic form, his memory of what he had just experienced. This very often required verbal explanations, as well as lines. When he had completed his drawing, he was requested to write out what he was doing to learn the maze and to analyze, so far as he was able, the entire process of meeting the situation.

After introspection and drawings were finished, a few minutes were allowed for relaxation and rest. The subject then returned

to the maze. After the next three runs were made, he again withdrew for drawings and introspection. This procedure was continued until the maze was learned. A maze was considered learned when the subject could run it five trials in succession without error.

C. Method of recording

For recording, the paths were numbered consecutively from the beginning to the end, odd numbers representing the true path and even numbers, the blinds. To make the records more accurate, segments of the paths were given sub-numbers. In this way, every part of the path traversed could be recorded. The system was thoroughly learned by the operator and the matter of recording was comparatively simple. The subject, of course, had no idea of the scheme used and only saw the unmarked mazes. Every segment entered and traversed one-quarter of its length, either in the forward or backward running direction, was recorded.

The possible errors are of two types, namely, (1) forward running errors, and (2) backward running errors, which are of two kinds (*a*) those which are retracings of the true path running back toward *A*, the beginning, and (*b*) blinds on the backward course to *A*. An error of the first type cannot be greater than the total length of one blind, nor less than one-fourth of one of the segments, which go to make up the blind. Errors of the second type are more complicated, because a backward running error may include segments of true and false paths, both backward and forward running, and may occur at any point of decision, in the true path or on emerging from a blind. Stating it more definitely, an error of this type consists of all of the paths entered from the beginning of the back tracing until the segment of the true path, formerly reached, is again taken up and the forward journey continued.

The data were tabulated in such a way that both group and individual treatment of the results would be possible. Not only is group behavior a truer criterion upon which to base principles of learning which would hold for the class, but idiosyncrasies of

individuals are lost in the totals and chance happenings have less weight. But to give averages or totals any weight, variations within the group must also be analyzed and, where the range of the variation is great, it must be explained.

D. Subjects

Students from the elementary classes in Psychology, most of them upper classmen, and a small group of graduate students volunteered to act as subjects. The graduates were trained in introspection and it was hoped that they might be helpful in interpreting results. No subject had had any previous experience with mazes and supposedly approached the problem without any preconceived ideas.

Seventy-five men and women were chosen for the experiments. This group was broken up into three groups of twenty-five each, the first to learn maze H and its modifications; the second, the A series of mazes, and the third, the B series. During the experiment, however, several subjects were dropped for different reasons, so that the groups did not remain of equal size. As they finally stood, fifteen subjects learned H, eighteen learned A, and twenty learned B. The discussion and conclusions are based on the results obtained from the smaller groups.

E. Comparison of methods of tabulating data to show relative difficulty of each blind

The amount of resistance offered by each blind may be indicated in three ways, namely, (1) by the total number of entrances made by all subjects while going in the forward direction, (2), by the number of trials necessary for learning to avoid it, and (3), by the total number of subjects having trouble with it. In the tables these are indicated as methods I, II and III respectively. The first two methods are probably more representative in that chance plays a smaller part in group treatment than individual. The findings were practically the same by all three methods as is shown by the high correlation between them (HI 0.947 P.E. 0.01517; A.I. 0.871, P.E. 0.0339; B.I. 0.941 P.E.

0.01429). Each method has its advantages, depending upon the comparisons made, but as every blind entered, even a so-called "slip," was counted in getting weights (values), the total-errors method is probably a little more accurate in that a "slip" can add only 1 error but may add few or many trials, which makes the penalty too heavy in some cases. The "trials" method is therefore slightly overweighted. For the third method the arbitrary standard of three or more consecutive errors per blind was taken as constituting a troublesome error and totals for the group for each blind were computed. Method III is valuable only as supplementary evidence as it gives no idea of the amount of trouble experienced by the individual subjects.

III. EXPERIMENT I, BASAL MAZES HI, AI, AND BI

The basal maze for this experiment was HI, a copy of which appears in figure 1 of the appendix. Results for the group by each of the three methods were tabulated. The summary tables are grouped and reproduced in the appendix for the reader.

Table 1 (see page 60) gives the total number of times each of the blinds was entered on the forward journey by the individual subjects (method I). For example, during the learning, subject HI entered blind 2, once; blind 4, no times; blind 6, 5 times, etc. The totals given at the foot of the table give the total number of times each blind was entered by all the subjects in the group. The footing headed rank a indicates the relative difficulty of each blind, using the total number of times it was entered as an index to the amount of resistance offered to learning. Ranks throughout this discussion are arranged in the same order, rank 1 corresponding to the lowest figure and the highest rank, to the largest figure; the results were arranged in order, from the easiest to the hardest, the low ranks corresponding to those errors which gave the least trouble and the high to those which gave the most trouble. Footing rank b indicates the relative difficulty of the blinds within half sections of the maze. This was done for further analysis and comparison within the maze.

Table 2 (see page 61) gives the total number of trials necessary

for the subjects to learn to avoid each blind (method II). For example, subject HI avoided blind 2 after the second trial, never entered blind 4, avoided 6 after the eighth trial, etc. The total number of trials for the group is found at the bottom and the ranks given on the basis of these totals are arranged and derived in the same way as in the previous table. It should be stated that the phrase "learn to avoid" is not strictly true to fact for the subject may not know the error he avoids and it is impossible in most cases to be certain, as there is nothing in his behavior to indicate that he is making a conscious choice in the sense of differentiating between the blinds and the true path. Passing a blind does not necessarily indicate that he has chosen in favor of the true path. This is not only true of the numerous instances where some errors are never made throughout the learning, but also in many cases where an error is made in several trials and then dropped, very often to be taken up again later.

The method of recording behavior in terms of the actual moves made, has limitations in that it may misrepresent the facts, except in those cases where the subjects volunteered further information, as often happened inasmuch as they were encouraged to think out loud. Interpretations based on such records are necessarily limited by the limitations of the method. This criticism of the method of recording is truer of the earlier stages of learning when the whole reaction is less definite and chance plays so large a rôle. It does not hold to the same extent in the end stages, when the subjects are consciously learning to avoid blinds. Introspection bears out the appearance that "learning to avoid" errors is much more active in the end stages for the entire attention is focused on a few "bad places." Here the records show more nearly what happens. What is meant then in the tables, is that after the trial indicated the error did not occur again and eventually was learned, but at which point there is no way to determine.

Table 7 (see page 66), gives the total number of subjects having trouble with each blind (method III) and is self-evident. Ranks were computed in the same way.

A. Discussion of results

By each of the methods analysis shows that certain errors stand out as particularly difficult and in each case the difficulty appears to be due to a combination of conditions—a uniqueness in the arrangement of the runs. These fall into two types, (a) those that diverged from the true path in the same direction to be taken at the next point of decision, the general direction of runs being the same in the case of blinds and the true path—(this is particularly true where the general direction for the limited area in which the blind occurs coincides with the general direction used in orientation for the end, examples, blinds 10 and 30) and (b) cases in which blinds were the same form (direction of alleys, number of turns and length) as the true path (example, blind 20). The maze also seems to be divided into sections—the boundaries being determined by certain long paths which, by their form, set up rhythms—the thing we had tried to avoid in drawing the maze for the experiment (examples, alleys 27, 29 and 31). According to the introspections, which are explanatory of the results recorded for this section, these runs immediately became points of reference. “This long swing helps a lot.” “When I get here I always know where to go next—it breaks the maze up into two parts.”

The first of the trial was spent in anticipating this area which had become a goal, and then in turn served as a starting point with the end, *B*, for its goal—which would amount to learning two mazes in succession. The learning was done in terms of orientation to the end *B*. The subjects stated that they definitely chose paths which seemed to lead in the general direction toward the end—which became a definite point of reference after the first trial. They never lost sight of the relative positions of *A* and *B* and the idea served as a constant guide in directing the tracing tube—as they visualized the field before them and worked in terms of the three points, *A*, *B* and their own position. This is an advantage not enjoyed by animals in the maze, at least not to the same extent. The question immediately arises—whether these conditions are inherent in all mazes or present

only in the particular one chosen. In order to test our interpretation of the results, two other basal mazes were drawn, in each of which it was aimed to avoid those conditions or sets of conditions which appeared to be responsible for these results. In drawing new mazes, the same principles were used in forming run-ways at points of decision, but complete rearrangement of alleys was necessary and all long sweeps were broken up by introducing several short turns, known as "kinks."

AI (fig. 4, page 82) was the second basal maze drawn. To blind 20 it was identical with HI, but at this point the arrangement and form of alleys were changed.

BI (fig. 7, page 84) was the third basal maze and was totally different, there being no points of similarity between it and either of the other mazes. It is much more difficult both in number of points of decision and actual length. The combination of runs also seems to be harder to learn—although this may be due to its increased length. It was made more difficult with the view to making the subject lose his bearings as it was thought that perhaps the problem of mastering a more complex situation would result in some confusion and delay orientation in terms of the end as the whole experience would tend to be less definitely formulated. Another attempt to break down their orientation was a change in the method of work. An experiment with a few subjects was tried in which the subject moved around the table as he worked his way along the paths—a necessary procedure if he were not seated, as the field was so large that he could not reach beyond the center unless he changed his position. It was thought that if his own position were not fixed it would be more difficult for the respective points of reference to assume such definiteness. It was found, however, that this arrangement made practically no difference. He oriented himself in terms of the four walls of the room and projected the maze before him as if he were standing still. Whether he actually moved about or not, the maze had a definite position in the room and the points *A* and *B* kept the same relative positions in terms of the objects in the room. Many subjects stated that they imagined themselves on one side of the maze and moved about with the fixed

position in mind. As this change in method made practically no difference in the results and did not accomplish what was expected, the experiments were continued with the old method, as it was less fatiguing and could be carried out more quickly.

Results for each of the mazes were tabulated in the same way as for HI. The summary tables are grouped and reproduced for the reader in the appendix.

Tables 3 to 10 (see pages 62-67) give the results by the three methods. Certain relations were found to hold for all of the mazes and in the remainder of the discussion the three are discussed together.

Tables 10, 12, and 14 (see pages 67-69) give the results combined to bring out the reactions within quarter sections of the maze and show the total number of errors per area made by each subject, and totals per area for the group.

Tables 11, 13, and 15 (see pages 67-69) show the number of blinds per area giving trouble after the fifth trial per individual and for the group. The beginning and the end were the first parts learned whereas the middle areas gave trouble throughout the learning period. The different tables bear this out, especially those marked *b* and *d*, which show clearly that even in those cases where the end sections gave considerable difficulty, it occurred only in the early stages of learning, a few trials being sufficient for these errors to be dropped, seldom if ever to reappear. These statements refer primarily only to two blinds at the beginning and two at the end as over against the remainder grouped in the middle areas.

On the whole the learning of the two ends proceeds equally with most subjects.¹ Where cases are counted, the greatest number (64 per cent) show equal gain for both ends but there are two small groups one (20 per cent of total group) of which shows a tendency to learn more rapidly at the beginning while the opposite condition is true of the other (15 per cent of the total group) with its more rapid acquisition of the end. The results for mazes HI and AI indicate that these individual varia-

¹ The complete records are on file in the general library of the University of Michigan and may be consulted by any interested investigator.

tions are probably due to chance as there were only a few subjects who learned one end more rapidly than the other; but results with maze B show that the learning was decidedly most rapid at the beginning, the end section giving much more trouble than the beginning. The group learning at the beginning almost equals the group learning evenly, which suggests that the pattern of the maze may be responsible.

While the middle areas in each of the mazes offered the greatest resistance to learning, they do not appear to be of uniform value. In HI the entire middle section seems to be of approximately the same difficulty as learning proceeded almost evenly throughout (note the curves, page 86), while in AI, the first half, and in BI, the second half of the middle section appear to be much the more difficult.

The graphs, fig. 10 (page 86), are plotted from tables 1 to 10 respectively and show graphically not only what is indicated in the tables but also the high correlation between the three methods of scoring.

The general facts brought out by the tables are as follows:

1. There is a decided tendency to learn the two ends of the maze first.

2. A relatively narrow memory span at either end is indicated in spite of the fact that no particularly difficult blinds (except in maze BI, blind 4) occurred at these points to account for this. This first and last two errors gave less trouble than any other in the maze and were likewise the first learned. In mazes HI and AI, 63 per cent of the subjects had no difficulty with the first and last blinds, after the second trial—62 per cent of these did not make either of these errors after the first trial. In 72 per cent of the cases, the second and next to the last were the second in order to be learned. These results correlate very well with the introspections in which all subjects stated that the beginning and end, two runs in, stood out very clearly in their memory—the last turns being made consciously and anticipated, but the first, automatically and without much appreciation of why the turn was made, the decision once made (first trial) seeming to leave them in possession of the correct habit without

their having to bear it in mind. Their feeling for the areas as a whole, after running both equally well, was not the same. Practically three-fourths of all the subjects said they felt thoroughly familiar with the end but not at all certain of the beginning where they still had to go carefully because of a feeling of uncertainty and the expectation of finding themselves in a blind, although there was nothing in their outward behavior to indicate that such was the case. The runs were made at approximately the same rate and with no apparent hesitancy at the points of decision, but in going from a known to an unknown (for the middle sections are hazy and practically meaningless far into the learning period) their anticipation of trouble gave them a feeling of uncertainty. In the end, the situation was reversed as they were going from an unknown into a known, for the goal always stood out plainly and served as a definite point of orientation, all turns being made with reference to it. Recognition of the familiar section gave them a feeling of security. The following comments are typical and confirm the results.

"The last is so much more familiar than the first."—BI.

"I feel as if I knew more about the end."—AI.

"I have the last in mind better than the first."—AI.

"I am right in the beginning but the end I am sure of."—HI.

"I know it better when I am near B."—HI.

"I am right at the beginning and the very end I am sure of."—HI.

The surprising thing is that the memory span is not larger. On the face of it, it would seem that more than two decisions could be kept in mind, but the explanation of this probably lies in the fact that the experience has no such definiteness for the subject. It is not a matter of remembering two decisions; he is reacting to the situation as a whole, and for him it is not a series of right and wrong paths with points of decision at irregular intervals. He learns to differentiate between segments, only with experience. He has neither the advantage of orientation in terms of the parts, nor an appreciation of errors as over against correct runs. To him an error is just as much a segment of the maze as the true path and points of decision may not be recog-

nized as such. They are often passed through without any decisions being made, the fact never being appreciated, especially if he happens to run into the true path. There is also the possibility of running into a blind alley without noticing at which point it was entered. Added to this, is the indefiniteness which results from the variation in his experience from trial to trial. Whatever the explanation, the fact remains that with most subjects, in mazes HI and AI the third errors from either end proved the first points of difficulty and required a great increase in the number of trials necessary for mastering them, with a consequent proportional increase in the total number of errors made at these points. While the span of immediate mastery at both ends is very narrow, study of the results both in actual errors made, introspections and drawings (see pages 86-87) shows that the areas extending in for some way from the ends are learned sooner and points in them are recognized and used in fewer trials than the same things in the middle sections,—all of which tends to show that the areas at both ends offer less resistance to learning. The following comments clearly show this:

“It is a very funny feeling—I can’t get places in between and some parts are so clear.”—HI.

“Through the middle I am all mixed up.”—AI.

“I am getting it in spots; every trip I pick up a little.”—BI.

3. The appearance of areas of greater difficulty in the middle regions, which seem to divide the maze into sections. There may be two or more of these areas varying in size. Some are relatively small but offer considerable difficulty, depending upon the sequence or combination of runs rather than relative position in reference to the beginning and end. This is borne out by the fact that in the three mazes none of the areas coincide. Areas 6 to 10 in HI, areas 10 to 20 and 30 to 36 in AI, areas 10 to 22 and 26 to 34 in BI may be taken as illustrations.

4. There is an apparent lack of uniform difficulty of individual blinds. Some gave much more trouble than their absolute position, length, number and direction of turns would warrant if the difficulty were equal. This is true, even if we allow for a

progressive increase in the resistance to learning offered by the paths as they approach the center of the maze. At first it was thought that there might be a progressive increase in the difficulty offered by the paths from the ends to the middle; but this cannot be proved to exist unless a maze made up of errors of uniform value could be drawn. However, our findings, as well as those of Peterson (17-21) seem to indicate that the difficulty of the blinds is not entirely dependent upon their physical characteristics, but is rather closely related to what precedes, the stage of learning and the habits formed. These would make the difficulty of a blind a variable and not a constant, as is inferred in most of the other discussions.

5. The errors of greatest difficulty without exception, wherever they occur in any of the mazes, are followed by a decided drop in the curve, showing that the error immediately following a difficult one is made the easier because of this relation.

Other experimenters with mazes (Carr (3), De Camp (5), Hubbert and Lashley (8), Peterson (17, 18, 20)) placed considerable emphasis on the physical characteristics of the blinds but most of the work has been done on animals. In order to determine whether the relations were the same with human subjects in a maze of fixed orientation, a study of the influence of these factors was made. The results show that the blinds are not uniformly difficult and the first analysis is aimed to determine how far this lack of uniformity was dependent upon physical characteristics of the run-ways.

B. Analysis of forward running errors based on physical characteristics

1. *Length of blind as a factor.* While the mazes were not drawn with this comparison in mind, the main emphasis having been placed on the points of decision where it was aimed to rule out the objectionable features of earlier mazes, it happened that many of the paths in the mazes were strictly comparable as far as physical makeup was concerned.

Our results indicate that length, as such, especially if considered irrespective of other factors, has little or no weight in determining

the resistance offered by an alley a result which is quite different from Dr. Peterson's in his experiments with rats (17) where length of runs seemed to be one of the most important physical conditions.

Correlation between length and resistance*

MAZE	METHOD I		METHOD II		METHOD III	
HI	-0.3285	P.E.† 0.13125	-0.3366	P.E. 0.13044	-0.1608	P.E. 0.1433
AI	-0.0212	P.E. 0.14056	+0.1447	P.E. 0.13766	-0.3202	P.E. 0.12619
BI	-0.1181	P.E. 0.1235	-0.1545	P.E. 0.1222	-0.1513	P.E. 0.12235

* The Spearman formula was used in the calculation of all correlations.

† Formula used $P.E._r = 0.6745 \frac{1 - r^2}{\sqrt{n}}$.

In eight cases the correlation is negative and in all, the correlation is so low as to be meaningless or without value.

Discussion of the individual blinds makes the point even clearer. If alleys of given length are of different weights, especially where the variation ranges from the most difficult to the least, the factor of length is not the important one, or its influence is being counteracted by something else.

In HI blinds 10, 12, 26 and 38 are of equal length and the shortest runs in the maze; but, they vary in rank, being 19, 11.5, 15 and 18 respectively (method I). All of them fall among the higher ranks, showing them to be difficult in spite of their being short. In AI the same is true of blinds 6, 10, 12 and 32, ranks 16, 22, 19 and 18 respectively, while in BI blinds 20, 26 and 38, ranks 16, 29 and 10 respectively, come under the same description. Because the first and last two runs are atypical, due to their position, they were omitted in a second series of computations. This omission makes no difference in the ranks. With one exception all retain high ranks (HI, 15, 7.5, 11, 14; AI, 12, 18, 15, 14; BI, 14, 25, 9).

Runs of approximately the same length, especially those ranging in the middle, have entirely different weights, varying from the most to the least difficult. In HI, blinds 24, 32 and 34 ranks 11.5, 16 and 13 respectively; in AI, blinds 26, 34, 36 and 42 ranks

3, 9, 12.5 and 21 respectively, and in BI, blinds 8, 24 and 40 ranks 10, 19.5 and 27 respectively, demonstrate this.

There are also instances of long runs being difficult and short ones easy, which precludes a positive tendency in either direction. Further examples only weight the evidence against length as such being a dominant factor in determining the amount of resistance offered by the blind.

2. *Number of turns in the blind as a factor.* Results for all mazes indicate that this factor as such has very little weight in determining the difficulty of a blind.

Correlation between number of turns and resistance

MAZE	METHOD I		METHOD II		METHOD III	
HI	0.0925	P.E. 0.14589	-0.1110	P.E. 0.14535	0.0837	P.E. 0.14609
AI	0.1210	P.E. 0.1385	-0.0822	P.E. 0.13969	0.0111	P.E. 0.14056
BI	0.0075	P.E. 0.12518	-0.0645	P.E. 0.12470	0.0142	P.E. 0.12518

The figures show no tendency in either direction; when the comparison is based on Rank by Trials, the correlation is negative, the less turns the greater the difficulty, but the figures are too low to be indicative, and while the correlation is positive when ranked by total errors, or total number of subjects having difficulty, the figures are again so small as to be without value. The relation can be made clear by citing cases in point. Blinds 2, 2 and 6 in mazes HI, AI and BI respectively have the greatest number of turns in the mazes, but the first two have low ranks, 3 and 5 respectively—later analysis shows that position in these instances is more important—whereas the last has a high rank, 22, in this instance direction outweighing turns.

In HI, blinds 22, 24 and 36, in AI, blind 30 and in BI, blind 44 have the fewest possible turns but the ranks vary, being 4, 11.5, 6, 11 and 24 respectively.

Great variation is shown with each combination. It was recognized that while many blinds have the same number of turns, they are incomparable in any other relation. In order to deal more directly with turns only, and to test the effect, similar blinds were compared. But even with the cases where

not only the number of turns, but also the general direction of the runs and form were similar (which makes the blinds more nearly comparable) the results show the same absence of relation between the number of turns and resistance; that is, comparable runs are of unequal weight.

Excluding the first and last two blinds and re-ranking do not change the relative values. It is obvious that number of turns as such is not an important factor.

3. *Position of blind in relation to beginning and end as a factor.* As the learning proceeded from both ends, the relative position of each blind is determined by its distance from the beginning or end, depending on whether it lies within the first or second half of the maze. Each half was analyzed separately, the totals by each method were re-ranked and the correlations which follow are between order of difficulty and position within the half.

Correlation between position and resistance

MAZE	FIRST HALF		SECOND HALF	
Method I				
HI	0.3575	P.E. 0.1860	0.4181	P.E. 0.17597
AI	0.3535	P.E. 0.1779	0.0659	P.E. 0.20248
BI	0.2373	P.E. 0.1701	-0.2076	P.E. 0.17246
Method II				
HI	0.4545	P.E. 0.1692	0.6909	P.E. 0.1114
AI	0.7181	P.E. 0.09849	0.2181	P.E. 0.1937
BI	0.4901	P.E. 0.13696	0.0296	P.E. 0.1801
Method III				
HI	0.4181	P.E. 0.17597	0.5241	P.E. 0.15466
AI	0.4909	P.E. 0.1543	0.2363	P.E. 0.19196
BI	0.2582	P.E. 0.1682	-0.2813	P.E. 0.16599

Here for the first time there is a difference in the results for each maze. In a few instances, there is an apparent tendency for the factor of position to have some influence in weighting errors, but in only two cases are the correlations high enough to show clearly a positive relation. Not only is there a variation

among the mazes but there is also a variation between halves in the same maze.

In HI position seems to have more weight in the second half, while in AI the opposite condition is true and the correlations in these instances are sufficiently high to be of significance, especially with the trials method. In BI the results show no tendency in either direction.

There were 11 blinds (10, 20, 30 and 38 in HI; 10, 20, 42 in AI and 4, 6, 26 and 52 in BI) that consistently with all subjects showed more errors than the position called for; but in each instance this apparently was due to certain peculiarities of the arrangement or sequence of paths or special swing which apparently surprised or confused the subjects.

Some difference between the correlations based on the three methods appears and in favor of the Trials Method, in spite of the fact that the correlation within halves between methods is rather high.

Correlation between methods (within halves)*

MAZES	FIRST HALF	SECOND HALF
HI	0.955 P.E. 0.0187	0.884 P.E. 0.0466
AI	0.724 P.E. 0.0967	0.95 P.E. 0.0198
BI	0.832 P.E. 0.0554	0.936 P.E. 0.0223

* Formula used for multiple correlation:

$$r_{xyz} = \sqrt{\frac{r_{xz}^2 + r_{yz}^2 - 2r_{xy}r_{xz}r_{yz}}{1 - r_{xy}^2}}$$

With two notable exceptions, the first and second positions at each end, the influence of position is not any more marked than the correlations show; but there is no doubt that the first and second positions in both halves have a decided influence, as the blinds having these positions are, without exception, the least difficult, and this is true even when they are among the longest (example HI blind 40, rank 2 by methods I and II) or have the most complicated turns (examples HI blind 2, rank 2 by all three methods and blind 42 rank 1 by methods I and II) or when there is a combination of these two conditions (examples

AI blind 2 rank 2 by all three methods and blind 46 rank 3 by methods I and III and rank 2 by method II).

4. *Directions of blind as a factor.* a. *Direction at point of entrance same as the general direction of the area in which it lies.* The general direction of the paths varies within different sections of the maze, and it is this general trend that is referred to in this comparison. For example, in HI the true path 1 through 19 is "to the right and down" and subjects very definitely oriented themselves accordingly. Their comments bring this out even more clearly than the figures.

"This breaks up into areas. First you have to go way over to the right side of the table, then to the very bottom and clear across, and then all the last is left and up."—HI.

"So far (third decision) I want to get down and to the right, but I don't know any of it. Must get through with the upper right corner before I go down."—AI.

"There are three general areas. I know when I have arrived in them. There is a feeling for the general direction but the details are not clear except for one or two decisions."—AI.

"Now I am getting a more general idea of true connecting links between the three areas."—AI.

"I have to get up in that corner before I can go to the bottom."
"I keep in mind the areas I am in and know the general direction I must take—first upper right, middle, down and across and up left side."—AI.

"I want to get down to lower right corner."—BI.

"I have to get down to bottom—then go up into middle before I go over into the right corner."—BI.

There is a marked change in the results in that positive tendencies appear, about which there can be little question. Evidently this is a factor that influences the resistance.

The fact that 83 per cent of all blinds having the same direction as the general direction of the area in which they lie, are among those giving the most trouble, while 75 per cent of those blinds whose direction is exactly opposite from that of the area in which they occur fall among those blinds which give the least trouble, strongly suggests that the factor of direction is

important. Analysis of the results for individual mazes as well as the analysis of totals for each of the three methods brings out the relation somewhat better, especially with mazes HI and AI where the correlation runs very high; and, while there seems to be less influence in BI, the figures run high enough to show a positive relation. In every instance where allowance is made for the difference in the number of blinds under consideration, there is more than twice the difficulty where the direction agrees with the area.

b. Direction at point of entrance same as that of the next correct turn. Again the figures run high and show a positive tendency. 78 per cent of the blinds having the same direction as that of the next correct turn fall in the high ranks while 81 per cent of those with direction the opposite from that of the next correct turn fall in the low ranks. Analysis of the results for individual mazes as well as the analysis of totals for each of the three methods brings out the same relation, in the case of HI running as high as 100 per cent. With the exception of BI where the results are positive but not as high as in the other two mazes, the difficulty is twice as great where the direction agrees with the next correct turn. Table 16 (page 70) gives the totals and ranks for all errors arranged in "direction groups." For easy reference the columns are explained in the legend at the bottom of the table rather than in the text.

When the two directions are compared, we have the following: Comparison of the figures (table 16, page 70) shows that the second "direction" factor is as truly important as the first, but the relation is not entirely clear because there is considerable overlapping. The figures alone do not show the extent of the difference unless it is noted that both directions are present in some of the blinds. While it is impossible to separate these influences on the basis of movements alone, the introspections show that probably the general direction had slightly more weight with most subjects.

"I can't remember these decisions but I am in the upper corner and have to get down."—HI.

"This sweep takes me across to the left side to go up even if the turn is wrong."—HI.

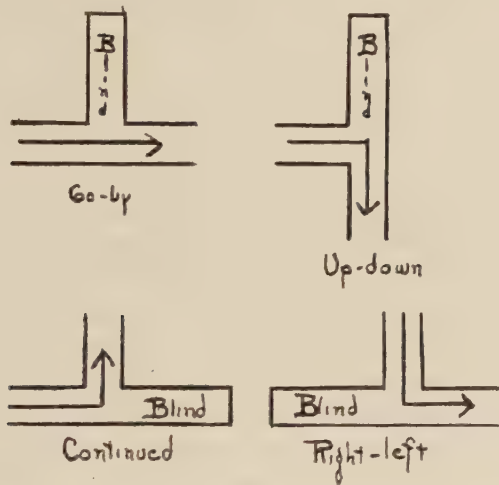
It is of interest to note that the two types of direction coincide in the cases of the most difficult blinds of each maze. (HI blinds 10, 20, 30 and 38; AI blinds 10, 12, and 20; BI blinds 26 and 52.) There are, however, two instances in one maze where this is not the case, namely BI 12 and 58, which fall in the lower ranks. Peculiarities of the blinds appear to be responsible for this. With 12 a third direction factor occurs which probably reduces the potency of the first two directions, that is, orientation within a larger area is influencing the decision. All the subjects immediately appreciated at this point that the true path ran across the top to the extreme side in order to work back across the middle. The position of 12 precluded this and was therefore avoided. With 58, which is over-weighted because of area relation, the effect is somewhat reduced because of the blind's position at the end of the maze, which has already been shown to be the most important factor.

Where allowance is made for the difference in the number of blinds under consideration, analysis of the totals for the three mazes shows the second direction (same as next correct turn) to be more difficult by all three methods, but the difference is slight. Analysis of the totals for each maze, however, shows a difference between mazes, in that direction of area gave higher returns in HI and BI by the three methods whereas direction of the next correct turn gave higher returns in AI. The difference between the results for the two directions in the three mazes is slight and the figures suggest that they are about equally difficult, although, as already indicated, the introspections suggest that area was more important in weighting errors and giving cues.

5. *Types of blinds as factor.* The blinds designated "Go-By" appear as a break in the true path and are to be passed. The so-called "Continued" are those presenting the opposite condition and appear as a continuation of the true path. T blinds or "Up-Down," "Right-Left" alleys appear as a sudden

splitting of the true path and may be in either of the two ways designated by the names. The first type, "Go-By," is the same as that described by Miss Helen Hubbert (7) in her experiment with rats where the reaction is referred to as instinctive.

The results are again suggestive of a positive relation. Without exception the Right-Left Type gave the least trouble regardless of the methods used to compute the resistance. The three methods agree throughout in the analysis of individual mazes as well as in the analysis of totals. While the tables show approximately equal distribution above and below the middle rank



for the other three types, analysis of totals for the group by each of the three methods indicates that the Up-Down was slightly more difficult than the other two, a relation that stands out quite clearly where allowance is made for the difference in the number of blinds under consideration. The order based on totals arranged from the most difficult to the least difficult is then Up-Down, Continued, Go-By and Right-Left.

Analysis of results for individual mazes shows the relation to hold in AI and BI by each of the three methods but in HI Go-Bys were slightly more difficult than Continued.

In the three mazes there are 27 of the Go-By Type. The ranks based on the three methods show approximately an equal

distribution for high and low ranks (method I, 13:14; method II, 13:14; method III, 15:12). With the Continued, however, (20 in number) there are twice as many having high ranks as low (method I, 13:7; method II, 14:6; method III, 13:7) suggesting that they are more difficult than the first type. Analysis of the actual amount of trouble shown by each of the three methods brings out the same relation but the difference is not so great. When allowance is made for the greater number of Go-Bys, the figures for Continued show slightly fewer errors (1255:1340) and fewer subjects having trouble (198:207) in spite of which there was an increase in the number of trials necessary to master them (3051:2931).

In the three mazes there are about an equal number of the Up-Down and Right-Left Types (13:14). Here the relations are entirely clear. With each of the methods totals for the groups show a decided tendency for the Up-Downs to fall into the higher ranks with four to six times as many of the Right-Lefts falling into the lower ranks, indicating that the latter offer decidedly less resistance. Analysis of totals for each of the three methods also bears this out. Without an exception, the figures are decidedly higher for the Up-Down Type and nearly twice the number of subjects had trouble with them (138:72).

6. *Comparison of types within the same maze.* In HI where the number of each type is about equally distributed, totals for each of the three methods show the Go-Bys to be the most difficult, with Up-Downs second, Continued third, and Right-Lefts fourth.

In AI the distribution of types is not so even but when allowance is made for this, Up-Downs are the most difficult, with Go-Bys and Continued about equally weighted, although the Continued appear slightly more difficult, (the total number of errors are the same but the number of subjects and number of trials are smaller). There is a decided drop in favor of the Right-Left Type which troubled the fewest subjects, had about half the number of errors and required the fewest trials.

In BI the distribution of types is so uneven that only a rough comparison is possible. When allowance is made for this differ-

ence, the Up-Downs are the most difficult by all three methods, the Continued second, Go-Bys third, and Right-Lefts fourth.

The total effect is not clear, however, because the types seldom appear uncomplicated. They occur in conjunction with other factors, especially direction, which was found to be the most important of the physical factors in determining the difficulty of a blind. It is true that the factor of direction does not appear alone but all tables show a strong positive tendency when either direction is present, whereas in the case of other factors there is no definite tendency which would make it appear that direction is the main influence. It is therefore reasonably safe to assume that when present, Direction rather than Type, is the primary factor.

7. *Analysis limited to pure types.* Examples of uncomplicated Go-Bys are 26, 32 in HI; 26, 28, 32 in AI; 10, 22, 46, 48, 50 in BI. In the cases where the type appears uncomplicated more of the Go-Bys rank low (6L to 4h) and since the direction raises the rank, as was shown above, where it appears in the combination with Go-Bys, the high ranks are probably the result of the former and not the latter. The exact relation, however, is not clear but it is definitely shown that the Go-By Type is not more difficult than the Continued (the distribution is about equal) which was not the case where rats were the subjects. Our results are positive to this extent. Examples of uncomplicated Continued are 28 in HI; 4, 24 and 38 in AI; and 24 and 44 in BI. Where the Continued appear uncomplicated the same thing appears as was shown with the Go-Bys, namely, a dropping toward the lower ranks (3L to 3h). In every instance where direction, either of area or the next correct turn, enters, and especially where both appear, the ranks are raised. Examples of uncomplicated Up-Downs are 14 and 18 in HI; 14 and 18 in AI; 30 in BI. With the uncomplicated Up-Downs the ranks are nearly evenly distributed (2h to 3L) although when directions were present they always ranked high. The Right-Left Type occurred most frequently uncomplicated by the factors of direction, there being but one blind of this type where direction was also present. Comparison based on results for individual sub-

jects shows the same relation, in that, the choice Right-Left remains the easiest throughout for all subjects (1h to 12L). In summary, when uncomplicated by direction, all types are of equal difficulty except Right-Left cases, which are easier than any others.

Regardless of type, the factor of direction weights the values; and, where both directions are present, the error falls into the highest ranks with the exception of two errors in BI (12 and 58) in which this is not the case, making an explanation necessary.

The introspections explain the situation somewhat. It appears that the subjects did not differentiate the paths in this way and scarcely noted these points. The subjects were oriented in terms of the entire maze which was made up of a few large sections which they pieced together to make the whole. They seemed to be focussed on larger elements than points of decision, at least the important part of the point of decision was whatever contributed most toward fitting it into its area; and, generally speaking, direction received the most recognition. It is of interest to note, however, that in the first trials minor features of each point of decision played a larger rôle than later in the learning process. Many subjects at first noted types and tried to learn the series (when they were able to formulate it so definitely) but were soon lost in the intricacies of the maze, the new experience piling up too rapidly for them to keep the scheme in order, it being beyond the memory span. They therefore gave up trying to memorize sequences of turns by descriptions. As the learning progressed, the tendency to notice small details became less and points of decision stood out, not in relation to themselves and their own characteristics, but to the whole. In other words we find much the same condition here as in the mental reaction to other learning problems, namely, a tendency to group things and get larger sections rather than details.

"I have an idea of the general direction though no details as yet."
—HI.

"I haven't the details but I know different areas and can put them together."—AI.

"It's just like three or four mazes strung together, but I can't remember any details."—BI.

The result is almost what might be expected. In the first trials an opening attracting attention might be explored simply out of curiosity to see what would happen, as all paths were unknown; but, having once ascertained the possibilities, the human subject inhibits, so far as his memory helps him, all acts except those that lead to the goal. He appreciates a whole and works in terms of it. It is because of this appreciation of a sequence that he shows superior ability.

Nine pure types, so-called because the direction at the point of entrance does not agree with the direction of the area or that of the next correct turn, appear to be exceptions to the above conclusion, in that, although direction is absent, the ranks run high. These blinds are 4 Go-Bys—26 and 32 in HI, 32 in AI, 22 in BI; 3 Continued—28 in HI, 24 in AI, 44 in BI; 1 Up-Down—30 in BI and 1 Right-Left—16 in AI.

Analysis, however, shows that the factor of direction *is* present, although not apparent at the entrance of the blind. In *every* instance the form of the alleys is either identical with the last few turns of the correct path just run or the length of one turn similar to the turns of the next correct path except for the direction of the entrances.

Direct comparison of combinations of runways makes this clearer. An example of the first is 31₁ in HI where 31₁, 32, 32₁ is the same as 27₂, 29, 29₁. Examples of the second are: 26 in HI where 25, 25₁, 25₂, 26 is like 29, 29₁, 29₂, 31; 28 in HI where 28, 28₁, is like 29, 29₂ and 31; 16 in AI where 13₄, 15, 16, 16₁ is like 17, 19, 19₁, 19₂; 22 in BI where 21₃, 22 is like 23, 23₁; 30 in BI where 29₃, 30, 30₁ is like 33, 33₁, 35.

In the first case the errors resemble carry-overs, possibly due to slight distraction or to automatic running. In the second the errors might be regarded as anticipatory and due to too hurried running, the association outrunning the tracing tube. The factor of direction can also be shown to be present in the other three cases. For example, the form of blind 32 in AI agrees

with the correct path just passed and except for the entrance, with the next part of the correct path to be reached in that 31₇, 31₈, 31₉ is like 32, 32₁ and 31₉, 32 is like 33, 33₁ 33₂. The entrance to blind 24 in AI is like the second turn of 25 and runs in the same direction as the area and that of the next correct turn. In blind 44 in BI the direction of the area is confused with the direction of the end.

There are also three Go-Bys (AI 28, BI 12 and 58) which appear to be at variance with the general conclusions made above in that in spite of being complicated by both directions, the ranks are low. The first two are atypical due to the sequence of paths and the third can be explained in terms of its position at the end, a factor which has already been shown to have the most important influence in lowering the resistance of a blind.

The same analysis was repeated within halves of the maze in order to see whether physical factors were any more important within the smaller units or were in turn influenced by their position in the maze.

8. Analysis within halves. Length. The correlations are practically the same as they were in the analysis of errors for the whole maze, the only exceptions being in AI first half method I, and HI second half method II, where the correlations run -0.5272 and -0.5696 , respectively, suggesting in these instances at least that the longer the blind the less the resistance.

Number of turns. While the correlations run slightly higher than in the analysis for the whole maze, they are less than $+0.3$, again being too small to be significant. No positive relation is shown in either half.

Direction. Comparisons by ranks show approximately three times as many high ranks as low where either direction tendency is present, and three times as many low ranks as high when direction is absent. Analysis of the individual totals within halves, allowing for the difference in the number of blinds under consideration, shows that the blinds having the same general direction as the area give more trouble than those having the same direction as the next correct turn. Where neither direction is

present there is a decided drop in the resistance offered. The results by the three methods again agree in this.

Analysis of totals for each maze shows a slight difference between the halves. In the first half the two directions appear to be equally difficult, in HI and AI, the totals by the third method being the same and in BI, the direction of area gave slightly higher returns by each of the three methods, whereas, in the second half, the direction of the area was decidedly more difficult in AI and BI, being almost twice as heavily weighted according to the totals; but in HI the direction of the next correct turn offered more resistance.

Types. Again each of the four types has both high and low ranks but the first three types have more among the high, while the fourth has more among the low. Allowing for the difference in the number of each type analysis of totals for the group for the first half shows Up-Downs to be the most difficult, Go-Bys second, Continued third, and Right-Lefts fourth. Comparison of the three mazes shows quite a little difference. Up-Downs were the most difficult in AI and BI, while Go-Bys were the most difficult in HI.

In the second half there were no Up-Downs in any of the mazes. In AI and BI, Continued were more difficult than Go-Bys by all three methods, but in HI, Go-Bys were again slightly more difficult than Continued. The Right-Lefts continue the easiest.

Summary. An analysis within halves shows no difference between halves for any of the physical characteristics—the weights remaining practically the same.

9. *Facts brought out by the drawings.* The drawings chosen for reproduction (figs. 15, 16, 17, and 18) present the various types of response. In making these, some of the subjects stated that they knew more than they could draw, while others were surprised at the amount they could reproduce, later stating that the drawings made certain points definite and helped to clear up hazy sections.

On the whole, mixed types were the most frequent but there were a few who were predominantly kinaesthetic and a second

group, predominantly visual. The former often preferred to make the drawings with the eyes closed (see fig. 15, chart 5) and the following comments are typical and frequent:

"My arm runs this. I'm all right as long as I don't try to decide."

"I feel these paths in my arm."

"Each time I try to go against the feeling of it I get into a blind."

The strongly visual subjects used minor blemishes or faint shadows in the paper; claimed to see the paths ahead and had "pictures" of "bad" points of decision. In their drawings they frequently indicated these with lines to show the blinds or blemishes. (See fig. 17, charts 13 and 14.) Verbal imagery, both motor and sensory, also played a part in the drawings as is shown in the following:

"I can't draw this unless I talk as I draw, like I do when I'm running the maze."

"It doesn't sound right"—from a subject who named each choice as he ran the maze—"up, up, right, left, down, etc."

The drawings all confirm the tables and graphs in several ways. The first thing that stands out is the definiteness of the beginning and end sections which are the first parts drawn correctly, and the haziness of the middle section (see figs. 15 and 17, charts 9 and 15), and the second, the breaking up into areas which are later joined together. Chart 7, figure 15, is included because it is an instance where the subject commented that he was so conscious of sections that he "had" to indicate them, and further that he knew each in order and its relation to the end. There is no doubt that the end served as a definite point of reference and the paths took on meaning in relation to it as well as to themselves. *All* of the subjects commented upon this when drawing.

The rapidity with which the details were appreciated and reproduced in the drawings so early in the learning period is the third outstanding fact—some subjects giving almost perfect tracings in the first drawing which was always made after the third trial. (See fig. 15, charts 4 and 8, both of which are more accurate than chart 6 which was made by another subject after

the twelfth trial.) Charts 9 and 15, figures 15 and 17, are typical for subjects who *felt* the uncertainty in the beginning (as given in their introspections) although their scores showed an equal gain for both ends. Instances of the beginning section being built up more rapidly than the end are less frequent but occasionally the drawings indicate that this was the case. All subjects were able to reproduce the correct path fairly accurately although some got more details than others and were able to do it in fewer trials. The drawings further indicate that the subjects' process is positive rather than negative in that they learned to select the true path rather than to avoid the blinds.

10. *Analysis of errors at various stages of learning.* With the hope of gaining more light on the learning process an analysis was made of the total errors at various stages of learning. Correlations were worked out between the performance of the first and last six trials on the one hand and the final scores for each blind in the whole learning period. It was found that those blinds in which the largest number of errors were made in the first trials were also, on the whole, those errors which persisted the longest and showed the greatest number of total entrances during the whole learning period, but, since this result is the same as is shown in other forms in preceding curves and statements, these correlations are not reproduced.

11. *Dropping blinds full length rather than gradually.* With rats, Peterson (17) found that the elimination of entrances to blinds did not come about mainly by a decrease in the number of entrances, but principally (especially in the case of the longer blinds) by a gradual decrease in the degree or the distance of the entrance. There is evidently a difference in the reactions for humans. Our results show that the blinds are eliminated by a decrease in the number of entrances.

In HI the total number of entrances for all blinds for all subjects was 1050, of these, only 26 per cent were entered part way, and of these latter, 67 per cent were not traversed more than one-quarter of the length of the 1st sub-runway. The remaining 33 per cent of partial entrances is made up of all runs covering more than one-fourth of the length of the first sub-division of

the blind, but the majority of them are not more than a fourth of the second sub-division. It was also noted that the subjects frequently hesitated at points of decision without entering the blind. There were 543 of these hesitations. Similar statements hold for the other two mazes.

AI total errors 1334, only 8 per cent partial entrances; of these, 68 per cent were traversed not more than one-quarter of the length of the first sub-runway with 296 hesitations.

BI total errors 2130; 22 per cent partial entrances; of these 68 per cent were traversed not more than one-quarter the length of the first sub-runway with 775 hesitations.

12. Frequency. Frequency has always been stressed as one of the important factors in learning. To test its value in this series the totals of right and wrong responses for each error on the three mazes were found. While the figures show that frequency of wrong responses may be greater than, equal to or less than the right responses, it is generally less—a condition which was found to be true in all three mazes, 66 per cent of the errors in HI, 82 per cent in AI and 68 per cent in BI showing greater frequency of right responses. Analysis also showed that where frequency of wrong responses was higher than or equal to the right responses it was always due to “bad habit” errors which were troublesome to most subjects. A habit error was arbitrarily defined as one occurring in three successive trials after the learning process has been well initiated. Where the habit errors are ruled out by deducting them from the total scores there are four instances where wrong responses continue to outnumber the right responses, namely, blinds 10 and 42 in AI and blinds 8 and 10 in BI.

With one exception all subjects had at least one habit error and some had many more than others. For instance, there were 12 subjects with 9 or more habit errors. The range 3 to 9 for HI, 1 to 11 for AI and 2 to 16 for BI indicates that the longer and harder the maze the greater the possibility of setting up wrong habits, probably due to the confusion with loss of orientation. It was also found that any blind might become a habit error, but the first and second in from both ends except in B were

least liable and the third in from the ends was most liable to have this occur. Certain blinds were particularly bad for setting up habits of this type and there were several in each maze, namely, 20, 30, 38, 10 and 6 in HI; 20, 10, 24, and 42 in AI; and 52, 26, 30, 4, 34, 12 and 40 in BI, named in descending order of difficulty. These so-called bad blinds generally bothered all subjects although they were not necessarily always habit forming. They are, with one possible exception (AI—24), dominated by one of the "direction" tendencies.

Analysis of the results for the first and second halves of the learning period for the whole maze showed that the number of errors were reduced in the last half period in *all* cases; but, where the learning period for each error (based on the number of trials necessary to eliminate that error) is considered as a unit, analysis by halves of such period shows a total of 15 in all mazes giving more trouble (whether measured by the actual number of errors, or the number of subjects having trouble) in the second half of the learning period than in the first half.

Further analysis of special errors considered for the learning period based on trials necessary to eliminate the error shows over a third of the subjects (HI 33 per cent, AI 31.9 per cent, BI 45 per cent having greater difficulty in the second half of the period in that there are more wrong responses in the second half as over against the first for these errors although there is final rapid gain in correct responses.

C. Analysis of backward running errors

As already indicated in the division on method, there are two types of backward running errors. Retravings occur not only upon emerging from a blind but also along the true path when the subject feels he is wrong although he has not struck a blind. For discussion, the former are designated as type I and the latter as type II (tables 17, 18, and 19).

In all mazes there were more forward than backward running errors and the most difficult maze, BI, showed the greater frequency of retravings. (HI, 1051 forward to 149 backward; AI, 1335 forward to 110 backward; BI, 2129 forward to 264 back-

ward.) Except in HI where there was practically an even distribution, there is a decided preponderance of the first type.

MAZE	TYPE I	TYPE II
HI	73	76
AI	81	29
BI	181	82

Retracings of the second type are related to special errors and areas rather than to the beginning or end of the maze. Certain points stand out as preëminently provoking this feeling of uncertainty and retracings occur frequently at certain points of decision, namely, 12-13, 34-35, 27-28, 29-30, in maze HI; 8-9, 12-13, 36-37, 4-5, 34-35, in maze AI; 48-49, 40-41, 44-45, 12-13, 19-20, in maze BI. As recorded, these appear in the order of their greatest difficulty. Backward running errors of this type never result in the same confusion as those following exit from a blind, probably because the situation is more definite and very limited in that the two possibilities offered at the point of decision can be kept in the focus of attention. If the subject runs into one of the openings and then decides he is wrong, the backing leads to the exploration of the second choice which in this case is a blind and because of the definiteness of the situation the backing is completed with the end of the blind for upon emerging he returns to his former choice, the retracing in this case being due to a temporary confusion, the result of faulty memory or faulty recognition cues. The subjects complained that these points are difficult to remember because both openings seem to offer equal attraction. It is of interest to note that these points correspond to those areas which are so closely related to the general direction either of the area or that of the next turn.

In HI, blinds 10, 20, 6, and 36, showed the greatest frequency for retracings type I. With the exception of 36, which is one of the five easiest, these correspond to the most difficult errors. On the other hand blinds 30 and 38 are also very difficult but gave no trouble in retracing. The same is shown in the other two mazes. For instance, in AI blinds 10, 20, and 32 gave the

greatest difficulty with backward errors type I but there was no backing with errors 16, 24 and 42 which were equally bad blinds. In BI blinds 52, 4, 26, 40 and 8 gave the maximum trouble in this way and with the exception of 8, which is one of the five easiest in the maze, these blinds were among the most difficult; but 6, 30, 34 and 44 were equally difficult and gave no trouble of this type. The greatest amount of retracing occurred in the first quarter of the learning period although 34 per cent of the subjects continued to make both types of backward running errors in the second half of the learning period. The number of subjects having trouble in the last half of the learning period varied with the maze, 12 per cent in HI, 7.2 per cent in AI and 2 per cent in BI. As to the amount of back tracing, the majority of subjects showed a retracing of one path or section of alley in both types. With Type II there was seldom a return of more than the length of three paths, whereas in type I, there was frequently a return of six paths, with one record of thirteen. There was much more confusion for both types in maze BI, the most difficult maze, and type I always resulted in more confusion.

1. *Further analysis of type I errors.* There was always more confusion where the retracing occurred upon emerging from a blind as over against a return on the true path. The relation between the relative difficulty of emerging correctly and the relative difficulty of an error is not as great as might be expected (as suggested above). In HI the correlation (+0.2299, P.E. 0.13935 method I; -0.0704, P.E. 0.1464 method II; +0.2691, P.E. 0.1365 method III) is so low as to be meaningless, while in AI (+0.5554, P.E. 0.09719 method I; +0.4921, P.E. 0.10658 method II; +0.4007, P.E. 0.11805 method III) and BI (+0.5322, P.E. 0.08977 method I, +0.4682, P.E. 0.0977 method II, +0.5316, P.E. 0.0898 method III) the correlations hover about 0.5. Comparison within the halves shows a higher correlation. This is particularly true and holds for the three methods in the first half for mazes HI and BI where the figures suggest that the most difficult errors give the most difficulty in emerging correctly. Figures for the second half are not so clear. In HI the correlation is negative and large enough to suggest that the more difficult errors give less trouble in emerging correctly. In AI the correla-

tions are positive and run higher than in the first half but are less than 0.5. In BI all correlations run less than 0.4.

An analysis was also made to determine whether there was any relation between the difficulty of emerging and the various physical characteristics of the blinds.

Length as such apparently has no weight. Note the low correlation (HI + 0.0247, P.E. 0.1382, AI + 0.3219, P.E. 0.12606, BI + 0.0374, P.E. 0.12505).

While the correlations involving number of turns run slightly higher, they are again too low to have significance. (HI + 0.3911, P.E. 0.1244, AI + 0.2958, P.E. 0.12828, BI + 0.3365, P.E. 0.1110).

Of the three physical factors position seems to be the most effective in weighting for difficulty of emerging but as in the other cases the correlation is low with the exception of AI first half where the figures are high enough to indicate that the difficulty increases from the beginning to the center.

MAZE	POSITION			
	First half		Second half	
HI	0.3667	P.E. 0.1846	-0.5121	P.E. 0.15736
AI	0.6523	P.E. 0.1168	-0.2409	P.E. 0.19156
BI	0.0495	P.E. 0.1798	0.2792	P.E. 0.16619

The correlations are negative in the second half but high enough to be significant only in HI. This relation is clearly shown in the curves (fig. 11) where it is seen that there was more difficulty in emerging correctly as the end was approached, a peculiar circumstance inasmuch as this area is one of the easiest sections to learn and it might be assumed that the subjects would not be so easily confused in so familiar a section. They continue to emerge incorrectly if they make an error after the section is nearly learned. It might be that an error in a familiar section is more apt to result in temporary confusion and faulty returns over paths traversed just because of the sense of security from which an error surprises them but this does not apply in the beginning where the maze is equally well known.

The great variation between mazes suggests that a combination of factors is at work rather than any one factor. Some of the tables show higher correlations for a given factor for one maze than either of the others whereas the same maze may have a lower correlation where another factor is under consideration. The sequence within a given maze may be responsible for this variation.

Direction. Direction seems to have less influence in weighting for emerging. While 56 per cent fall into the higher ranks where the direction is the same as the general direction, 50 per cent of those with opposite direction also fall into the higher ranks. Where the direction is the same as that of the next correct turn, 50 per cent fall into the higher ranks; where the direction is the opposite, 88 per cent fall in the lower ranks. Therefore it would seem that the second type of direction has a little more influence but the relation is not constant.

2. *Comparison of the totals for individual mazes.* If allowance is made for the difference in number of errors under consideration, analysis shows that, where either direction was present, there was always more retracing; and, the general direction of the area was more important than the next correct turn in increasing the difficulty.

For the analysis of types only those blinds which are uncomplicated by direction were included. Sixty per cent of the Go-Bys and 83 per cent of the Continued fall into the lower ranks for difficulty of emerging while 100 per cent of the Up-Downs fall into the higher ranks.

3. *Summary.* Position and direction may have some weight in increasing the difficulty of emerging, but the relation varies between the mazes and within halves.

IV. EXPERIMENT II, ADAPTING TO CHANGES

A. Modification of mazes

For this part of the experiment the apparatus remained the same, but modifications of the original mazes were used to test out the effect of partial changes upon learning. The modifica-

tions were made in different areas but the changes always consisted of closing what had been the correct path in the original maze and opening what had been a blind, which would reverse the choice at the points of decision in the changed areas. In order to determine whether the position, amount and order of change would make any difference, the changes were varied in each of the series.

The procedure was the same throughout. Each subject learned one series of mazes, three at one sitting and in the order indicated by the Roman numerals.

In learning the modifications of the original maze, four types of response appeared:

In type IV, the subjects recognized the changes immediately and made errors only in the area of difference, dropping them precisely without further trouble on either side.

In type III (a) the response was a little less exact in that the areas of difference were not so clearly differentiated, with the result that blinds in the neighborhood were entered showing slight confusion as over against the precision of the response in type IV. The old habits interfered with the new. Weak spots in the familiar sections also gave trouble and for purposes of description are indicated as type III_b.

In type II, there was a definite carry-over from the earlier experience which interfered with the new learning, resulting in the old alleys—formerly correct and now blinds—becoming persistent errors.

In type I, the earlier experience appeared to interfere with the new adjustments although the modifications were not appreciated as such by the subjects who had to learn the entire maze as if it were new. They seemed to get neither similarities nor differences.

Analysis of errors in the neighborhood of the changes shows three types of difficulties: (1) The first, the so-called hold-over errors where there was trouble righting themselves upon emerging from a changed area, due to failure to recognize the old path following the changed section. There was of course, no such definiteness for the subject. (2) The second, the anticipatory errors, those made in a familiar area immediately preceding the

area of difference in anticipation of the changes expected. (3) The third, confusion in the old areas outside of the sections immediately preceding or following the areas of difference. It was found that this type of trouble only occurred with those blinds which had given trouble in the original mazes. They were obviously weak spots which came to the surface when the adaptations complicated the problem and interfered with the "setting process," which resulted in the old sections having to be re-learned in part. There were over twice as many hold-over errors as anticipatory (31:13), in spite of there being fewer opportunities to make them, showing that the beginning of a change is more quickly recognized than the end.

B. Discussion of results with individual mazes

I. B. series (the longest and most difficult maze but having the least modifications). In this series the first modification, BII, (see figure 8, page 84) consisted of changing the middle section of the maze, the beginning and end remaining the same as in BI. BIII (see figure 9, page 85) was the same as BII in the beginning and middle sections but the end was changed. The beginning was the same in all three mazes of the series but the first change occurred in the middle section and the second change occurred in the end sections.

In BII (see tables 20 and 21, pages 77 and 78) eight of the twenty subjects adapted without difficulty in any area outside of the changed part and four had no difficulty with anticipatory or hold-over errors, although there was slight difficulty with weak spots in the old sections, showing that twelve of the group clearly appreciated the differences and were able to drop errors precisely (type IV). There were seven subjects with anticipatory errors and three with hold-over errors, indicating that the area of change was appreciated as such but was not so clearly defined (type III_a). Two subjects had difficulty with weak spots in the familiar areas but there was no instance where there was so much interference that it resulted in having to learn BII as if it were a new maze (type I).

In BIII (see tables 22 and 23, pages 79 and 80) there were no

anticipatory errors, the changed section being differentiated immediately. There were no errors in the beginning which was the same as in BI and BII, and thirteen of the subjects had no trouble in the middle section which differed from the same area in BI but was the same as in BII. With the remaining seven, the extra strain appeared to throw out the weak spots in the section which had just been acquired although the confusion was very short lived and the subjects quickly righted themselves. There was but one subject with as many as three errors and only two who took more than four trials to recover themselves.

Adapting to the changed center proved more difficult than adapting to the changed end, whether measured by the number of subjects having trouble, the actual number of errors made or the total number of trials required for learning. Other things being equal, it takes fewer trials to learn a third maze because of the practice, and it might have made a difference had the order been reversed; but, where the change comes at the end, there is less opportunity for difficulty, as but one type of error is possible; namely, the anticipatory, and this in itself favors the end position, reducing its resistance. Moreover, the tendency to learn from both ends also favors adaptation to changes in this section. The following brief summary in the form of a table brings out the relation between BII and BIII:

MAZE	TOTAL ERRORS	TOTAL TRIALS	MEDIUM TRIAL	RANGE (TRIALS)
BII	198	112	5	2-10
BIII	163	85	4	2-9

For graphs see figure 14, page 90.

II. A Series. The first modification in this series was also in the middle section, AII (see figure 5, page 83) having the same beginning and end as AI, but the middle was new. AIII (see figure 6, page 83) was a modification of AII but had a double change in contrast to the single change in the B series, the middle section remaining the same as AII, but the beginning and end sections were changed, so that AIII is totally different from AI.

In AII, four of the eighteen subjects appreciated the changed

area immediately (type IV); seven had difficulty in the weak spots in the old sections (type III_b), seven adjusted a little less accurately and also had minor trouble in the familiar area (type III_a and III_b), but there were more carry-over errors than anticipatory (8:2), indicating that the beginning of the changed area was more quickly differentiated while the end section was not recognized as such, the similarities not being recognized as quickly as differences, probably due to the "set"—the subjects' attention being focused on differences. In spite of this, eleven subjects had some minor difficulty in the beginning sections and eleven had difficulty with the end sections, the two areas proving about equally difficult. While there were none who had to learn the whole maze as if it were new (type I), three subjects had considerable difficulty with weak spots (type III_b), but even so, had made the adjustment in four trials.

In AIII, eleven appreciated the areas of differences and made neither anticipatory nor carry-over errors but seven of these had trouble with the weak spots in the old section. There was considerably more confusion with the double change and there was so much interference that four of the subjects reacted as if this were a completely new maze (type I). Again, there were more carry-over errors than anticipatory, the same as in all modifications, suggesting that it is easier to recognize the beginning of a modification than to appreciate its end. In spite of this and the fact that there were actually more errors, there was only a slight increase in the number of trials necessary to make this adjustment. This is brought out clearly in the following table:

MAZE	TOTAL ERRORS	TOTAL TRIALS	MEDIUM TRIAL	RANGE (TRIALS)
AII	234	102	5	3-10
AIII	372	105	6	3-11

Changing both ends left a much smaller familiar area but in spite of this, more errors (76:55) were made in this section than in the familiar areas in AII where there was twice the opportunity for confusion. (For graphs see figure 13, page 89.)

III. H series. This series was quite different from either of the other two. The beginning and end sections were changed in HII (see figure 2), the middle remaining the same as in HI, while in HIII (see figure 3, page 82), the beginning and end were the same as in HI and the middle section was new. In other words, each modification in A and B grew out of the preceding maze whereas in the H series, each modification reverts to the original maze of the series. In A and B, the first modification was made in the middle. The second modification in the A series, consisted of a change at the beginning and end, while in the B series the second modification was made only in the end section. In the H group of mazes, the middle section was the last modification made and both ends were changed at the same time in the first modification.

In HII the results resembled those found for the second modification of A, namely, greater confusion in the known area, twelve of the subjects showing type III_b responses, and while seven of these made carry-over errors, only one made an anticipatory error, and two of the subjects differentiated precisely (type IV). Only one subject failed to appreciate the similarities and learned the modified maze as if it were new (type I). The change coming at the beginning seemed to result in some confusion which spread over into the familiar area, but it was of comparatively short duration. The number of blinds giving trouble range from two to seven per subject, but the median number of trials necessary for righting themselves was three. There was only one subject with anticipatory errors but seven had carry-overs.

In HIII, type III_b responses were again most frequent, eleven of the fifteen subjects reacting in this way. There were no anticipatory errors but the beginning section gave more difficulty than the end—in both sections the errors made were retained from HII. With but two exceptions, there was but one error per blind and these occurred within the first three trials. There were three instances where the differentiation was made at once (type IV) and one instance where the similarities were never appreciated (type I), but there were no pure type III_a

responses, although there were three mixed responses (III_a and III_b). In spite of the fact that HIII reverts to HI , and HII was learned between HI and HIII , there was less trouble in adapting. The total number of errors and the total number of trials were both slightly less. Although the opportunities for errors in the old section in HII were only three-fourths as great as those in HIII , more errors were made (81:73), the changes in the beginning proving more confusing than the others. The above conclusions are clearly brought out by the following summary table:

MAZE	TOTAL ERRORS	TOTAL TRIALS	MEDIUM TRIAL	RANGE (TRIALS)
HII	191	86	5	3-11
HIII	180	77	5	2-11

For graphs see figure 12, page 88.

C. Analysis of combined results of the three series

Type III_b was the most frequent, 56.6 per cent of the subjects responding in this way with the first modification and 50.9 per cent in the second. Type IV was second with 26.4 per cent in the first modification and 37.7 per cent in the second. Type III_a was third with 15 per cent in the first modification and 1.8 per cent in the second. Type I ranked fourth with 1.8 per cent in the first modification and 9.4 per cent in the second. It would be more accurate to say that mixed types were more frequent: for instance, 30.1 per cent of those in type III_b also made anticipatory and carry-over errors, suggesting that they appreciated the changes. There were four instances where there was slight difficulty in the old sections, (type III_b) but the differences were appreciated at once so that these subjects should not be placed in the unmixed group. This would raise the figures for type IV to 30.1 per cent for the first and 41.5 per cent for the second. Human adults appreciate differences immediately and are able to make use of similarities. There was very little confusion and in every instance there was a decided drop in the

number of trials necessary for the learning. This is clearly brought out in the following table:

Average number of trials

HI.....	17.8	HII.....	5.9	HIII.....	5.0
AI.....	18.2	AII.....	5.6	AIII.....	5.8
BI.....	18.5	BII.....	5.6	BIII.....	4.2

The adjustments were made very readily, 41.5 per cent of the subjects mastering the modifications in three trials each, 69.8 per cent getting the first modification and 79.2 per cent the second, in five trials.

In those cases where there was so much interference that the modified forms were learned as if they were new mazes, the number of trials was very much reduced as over against the number necessary for the learning of the original maze. This is shown in the following summary:

Average number of trials

HII.....	11	HIII.....	11.0
AII.....	(no cases)	AIII.....	6.5
BII.....	(no cases)	BIII.....	(no cases)

The subjects' introspections bring out the situation even more clearly than the figures and if their responses could be based on these, all but eight accurately appreciated the changes and at the end of the first trial all subjects remarked about the similarities between the mazes. The following comments are typical and represent the reactions of the entire group:

"Why, there are only two or three places that are different."—AII.

"I used to do this in the other but it's wrong now."—BII.

"Why, you just changed the ends."—HII.

"It's something like the other one. Why, it is like the first except here (beginning)."—HII.

"The middle is the same as the second maze and the changes at the beginning and end are opposite from the old ones."—AIII.

"Up to here (36) it is exactly like the second."—BIII.

"This is just like the first except three places in the middle."—HIII.

"Parts are very similar to the first maze but the old way (38) is now right."—HII.

"The beginning and end are different. All the rest are alike."—HII.

Their drawings (see figure 18, page 92) also show how quickly the differences were appreciated and the accuracy with which they could place them.

D. Backward-Running Errors

In spite of the problem introduced by the changes which might have resulted in confusion, there was surprisingly little retracing. The total number of forward running errors in the second modification, combining the results for the three mazes, was 623 while the total number of backward running errors was 45. Type I was more frequent (28:17). The figures for the second modification bring out the same relation, with 715 forward running errors, and 64 backward running errors, (51) were type I, and 13, type II). By this time the subjects were fully adjusted to mazes and were for the most part able to keep their orientation. Where retracings occurred, 81 per cent soon righted themselves and did not go back beyond two paths.

E. Summary of results for experiment II

1. Whether a double change is made in the first or second modification of the series makes no difference, apparently, as in both instances the double changes resulted in greater confusion.

2. Whether the second modification grew out of the preceeding maze in the series or reverted to the original maze makes little difference, probably because of the very rapid appreciation of differences and similarities.

3. Where but one change at a time was made, it was more difficult to learn the modification in the middle section than the modification of the end.

4. In every modification there were always more errors made in the changed sections whether the areas were greater or less

than the old sections, definitely indicating that similarities were appreciated and used as such.

MAZE	ERRORS IN OLD SECTIONS	ERRORS IN NEW SECTIONS	MAZE	ERRORS IN OLD SECTIONS	ERRORS IN NEW SECTIONS
HII	81	110	IIII	73	107
AII	55	179	AIII	76	296
BII	37	161	BIII	16	147

5. In the modifications, direction again was an important factor in weighting errors. In every instance the most difficult error had the direction of the next turn or agreed with the direction of the area, but the situation is more complicated in the modifications where old habits have to be inhibited because of the reversed decisions, and even where both directions are present, it is probable that habit played as great a part in weighting the errors.

6. With the exception of carry-over errors in the old areas, the errors in the old areas giving the greatest trouble were always the most difficult errors in the original learning.

7. It also appears that a bad error, whether in the new section or the old, is generally followed by a drop in the curve, points of difficulty again serving as cues which helped in orientation.

8. There was a decided decrease in the number of backward running errors and very little confusion.

V. SUMMARY AND CONCLUSIONS

In the study of the physical characteristics, the effects of all factors were so obscured by "direction" that no definite relations could be shown to exist except in the case of the first and last two blinds which were the first to be eliminated. This interference holds throughout the learning period. A study of errors at the various stages analyzed showed direction to be the dominant factor which determined the elimination of errors, and it continued active throughout the learning period. The relation of frequency to the process of learning was also found to be complicated by fixed orientation. Some of the more difficult blinds

were entered more frequently than avoided, in spite of which they were learned. But again it was one of the "directions" which made them persistent, even where they could not be referred to as "habit" errors.

Analysis within halves brought out nothing which had not already been found in the study of the results for the whole maze. Drawings and introspections only confirmed the important part played by fixed orientation. The true path was the part appreciated by the subjects. Few even indicated the points where blinds intersected the true path, suggesting that the process is positive rather than negative in that the subject learned to select the true path rather than to avoid the blinds. Alleys were dropped full length rather than by segments. Over 80 per cent of the errors were dropped without partial entrance.

The backward-running errors were decidedly less frequent than the forward-running and were eliminated earlier in the learning period. The subjects showed very little confusion and righted themselves upon retracing in one or two sub-run-ways, but there was decidedly more confusion from making the wrong turn upon emerging from a blind than from retracing in the true path. It was again suggested that the factor of direction increased the difficulty of emerging.

In learning modifications of the original maze, the subjects appreciated differences almost immediately and there was little confusion in the old sections. The small amount present was largely due to anticipatory or carry-over errors, the result of slightly inaccurate placing of the changed sections. The carry-over errors were more frequent than the anticipatory. There was always more trouble in the new sections, whether the changed areas were greater or less than the old sections. Modification of the middle area offered the greatest difficulty. The sequence of changes seemed to make no difference. In every instance the most difficult error had the direction of the next correct turn or agreed with the direction of the area in which it occurred. The situation, however, in these experiments is more complicated than in the original learning because allowance has to be made for the inhibition of old habits.

This study clearly demonstrates that the maze with fixed orientation offers quite a different problem from that of the animal mazes where there is little if any fixed orientation. Results from the one field cannot ordinarily be used to interpret the other unless conditions are made more comparable. Moreover, modification of some of the conclusions in regard to human reactions in a maze is suggested, for the factor of orientation has not usually been considered.

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APPENDIX

TABLE 1
Maze HI. Number of entrances per blind by individual subjects. Method I

SUBJECTS	BLINDS IN SERIAL ORDER																	
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
H1	1	1	5		4	1	3	4	2	4	1	2	2	4	5	2	2	1
H2	2	1	4	1	1	4	1	1		6	2	4	2	3	5	1	1	4
H3			3	2	5	1	2	6	1	4		5	3	2	3	3	2	1
H4		1	1	3	5	2	2	2	4	6		1	2	3	3	2	2	2
H5	1		6	1	6	2	6	1	7			2	2	3	3	5	1	1
H6	2		1	4	6	2	5	2		5	3	4	4	1	10	2	2	1
H7	1		5	2	11	1	2	1		6	4	4	3	2	4	7	4	2
H8	1		1	4	3	2	4	3	6	4	4	3	3	3	4	1	4	2
H9	2		5	1	7	3	1	3	2	5	1	5	1	2	6	3	1	1
H10	2	1	9	7	2	9	2	4	3	12	3	2	6	3	8	7	2	3
H11	3	3	8	7	5	3	5	6	1	4	2	2	6	4	12	5	4	6
H12	3		8	6	7	8	4	2	7	4	2	4	8	5	5	2	3	11
H13	1	1	4	2	5	1	4	1	3	11	8	2	6	4	6	7	9	1
H14	1	1	7	10	15	4	2	2		8	3	6	5	3	10	13	5	10
H15	2	1	4	5	9	5	4	3	6	10	1	2	7	2	14	4	6	7
Totals (1050)...	22	9	71	55	87	48	47	39	42	95	24	48	57	44	91	59	54	35
Rank a.....	3	1	17	14	19	11.5	10	7	8	21	4	11.5	15	9	20	16	13	6
Rank b.....	2	1	8	7	9	6	5	3	4	10		5	7	4	10	8	6	3

Total number of errors for all subjects, 1050.

Totals = total number of entrances per blind for all subjects.

Rank a = ranks for whole maze arranged in ascending order of difficulty.

Rank b = ranks within halves of the maze.

TABLE 2
Maze H1. Number of trials per blind by individual subjects. Method II

SUBJECTS	BLINDS IN SERIAL ORDER															
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32
H1	2		8		6	2	5	8	5	7	2	5	7	10	10	4
H2	3	3	6	2	4	7	2	3		8	4	8	10	8	7	3
H3			5	4	7	4	7	9	6	7		8	8	5	6	4
H4		3	8	5	10	8	7	4	6	10		2	3	6		3
H5	2		12	4	3	3	11	2	12	10		10	4	8	7	7
H6	8		8	8	7	13	11	12		8	7	9		2	14	9
H7	2		10	4	14	2	6	2		16	9	14	16	10	13	9
H8	2		2	8	10	15	9	12	9	12	7	5	8	10	5	3
H9	16		13	5	9	12	2	11	11	10	2	7	2	3	16	10
H10	3	2	12	12	4	18	5	9	9	18	7	8	13	5	13	11
H11	4	15	20	9	15	10	10	11	10	10	7	8	17	18	19	9
H12	7		14	15	17	18	8	4	9	13	6	20	20	20	13	4
H13	2	2	6	3	7	6	7	4	8	16		11	15	11	13	11
H14	2	2	12	24	22	13	22			24	11	25	23	24	18	18
H15	5	2	7	7	18	16	11	5	15	18	2	17	22	14	19	24
Totals (2474)	58	29	143	110	153	147	123	96	100	187	64	158	168	154	155	119
Rank a	3	1	13	9	15	14	11	7	8	21	4	18	20	16	17	10
Rank b	2	1	7	5	9	8	6	3	4	10		8	10	6	7	4

Total number of trials for all subjects, 2474.
Totals = total number of trials per blind for all subjects.
Rank a = ranks for whole maze arranged in ascending order of difficulty.
Rank b = ranks within halves of the maze.

TABLE 3
Maze A1. Number of entrances per blind by individual subjects. Method I

SUBJECTS	BLINDS IN SERIAL ORDER																						
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46
A1	1		5	3	9	4	7	6	7	9	1	7	1	5		5		6	1	1	9	3	
A2	2	5	5	2	5	5	2	2	3	3	3	9	1	1	3	3	2	2	4	2	3	6	3
A3		2	2	4	4	4	3	1	1	5	4	4		1	2		3	1	2	2	3	1	2
A4	2	1	1	2	4	2	3	1	1	3	3	1	1	1	2	3	2	4	3	3	1	3	2
A5	1		3	1	6	5	2	6	1	4	4	4	1	3	2	2	2	2	1	1	2	1	
A6	2		4	5	4	5	3	3	2	9			3	3	5	6	3	6	3	1	3	2	
A7		1	2	2	2		3	6	1	2	2	2	1	2							2	1	1
A8	2		4	2	5	3	4	2	8	4	5	8	4	5	3	4		3	3	3	3	1	
A9	1	3	4	5	7	5	9	8	6	12	6	5	4	3	1	2	4	7	5	2	12	4	2
A10	2		1	6	12	8	3	6	2	6			1	3	1	8	1	3	1	1	6	1	1
A11	1		1	4	4	3	3	5	2	8	2	3	3	1	1	4	3	8	3	2	7	4	1
A12	5	3	9	7	5	9	5	12	1	10	3	6	3	4	5	6	3	9	1		7	8	1
A13		2	6	2	7	3	1	5	1	6	4	1			3	1	2	2	1		3		
A14	1	1	3	1	5	2	6		2	8	1	3			2	7	2	1	3		7		
A15	2		4	10	8	11	4	7	2	5	2	11	2	1	14	6	2	2	1		11	2	4
A16	1	1	6	5	10	5	1	6	7	12	5	2	1	5	1	10	1	2		1	2		2
A17	1		6	3	12	4	5	2	10	10	6	4	3	1	7	5	5	2			8	1	1
A18	3		3	5	5	1	1	4	4	6	4	5	3	2	3	4	4	1			6		2
Totals (1334)....	27	19	69	64	114	79	65	82	61	122	55	75	22	38	58	78	40	61	29	19	95	38	24
Rank a.....	5	1.5	16	14	22	19	15	20	12.5	23	10	17	3	7.5	11	18	9	12.5	6	1.5	21	7.5	4
Rank b.....	2	1	.7	5	10	8	6	9	4	11	3		2	5.5	8	10	7	9	4	1	11	5.5	3

TABLE 4
Maze AI. Number of trials per blind by individual subjects. Method II

SUBJECTS	BLINDS IN SERIAL ORDER																						46
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	
A1	3	12	8	14	13	15	15	17	14	17	12	18	3	9		16		10	4	6	14	9	
A2	3		11	3	10	9	6	3	7	8	9	13	2	4	10	8	3	5	5	5	5	11	
A3		3	9	7	5	7	7	7	7	6	7			4	4		4	5	9	8	6	2	
A4	3		3	5	8	3	6	2	6	5	7	5		5	6	9	8	7	5	8	8	6	
A5	2	3	4	2	9	15	4	8	2	12	9	12	3	10	9	6	5	3	2	2	5	2	
A6	4		10	6	6	7	11	10	9	13			9	6	10	12	8	10	9	8	7	6	
A7		2	3	7	6		4	8	2	5	6	7	2	3	10	3				8	4	4	
A8	3		7	9	10	8	6	9	12	9	11	13		8	8	8	7		8	3	8	2	
A9	2	7	9	18	10	19	18	15	16	17	10	16	6	10	9	9	9	10	8	3	18	21	
A10	3		5	10	18	23	18	22	8	21			7	22	17	21	4	6	2	2	20	2	
A11	2		8	8	6	6	16	11	12	16	15	11	2	5	8	12	13	15	5	6	13	7	
A12	16	14	19	12	9	17	17	24	4	17	16	20	15	17	23	17	12	24			11	11	
A13		5	11	4	8	6	5	8	3	7	12	12			9	2	8	4	4		4	3	
A14		2	4	2	8	4	12		4	12	4	13			15	14	9	5	8		9		
A15	3		6	22	10	20	16	17	13	18	19	23	3	3	25	25	12	4	2		16		
A16	2	2	10	18	18	17	2	18	18	15	15	7	5	13	10	14	4	9		7	6	4	
A17	2		12	10	24	20	13	5	25	13	23	12		4	23	7	9	9			9	9	
A18	5		9		10	4	5	14	13	13	10	13	7	7	7	5	5	8			10	8	
Totals (3269).....	55	50	148	157	188	200	181	198	170	225	184	202	64	122	193	188	113	141	67	63	171	92	
Rank a.....	2	1	11	12	17.5	21	15	20	13	23	16	22	4	9	19	17.5	8	10	5	3	14	6	
Rank b.....	2	1	3	4	8	10	6	9	5	11	7		2	7	11	10	6	8	3	1	9	4	

TABLE 5
Maze BI. Number of entrances per blind by individual subjects. Method I

SUBJECTS	BLINDS IN SERIAL ORDER																													
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	
B1	5	2	4	1				2	9	3	1		2	6	4	2	4	2	3	1		5			1	8	2	4	3	
B2	2	2	4	3	2	6	4	2	3	3	8		2	8	7	1	3	6	1	2	5	5		1	2	12	3	1	2	
B3	4	2	1	3	1	1	3	4	1	2	2	2	12	6	4		4	8	2	3	4	4	2	2	2	5	1	2	4	
B4		6	2	5	1	2	1	1	1	2	1	1	2	3	4	1	4		2	4	2	4	1	1	1	3	8	1	4	
B5	4	4	3	3	3	3	1	3	5	1	3	1	4	2	4	3		3		5	1	1	3	4	1	2	3	3	3	
B6	2	1	4	4	3	4	4	2			3		5	1	5		1	3		4	3	2	4	3	4	7	1	4	1	
B7	1	9	4	4	4	5	1	2	6	6	2	3	9	3	6	1	6	2		2	3	5	1		1	7	2		7	
B8		7	3	4	1	1	9	12	4	7	8	5	13	13	10	3	11	7	2	19	13	7	2	6	4	15	4	10	4	
B9	2	9	7	2	2	4	3	2	6	3	5	2	5	12	10	2	7	2	2	8	6	7	7	1	3	5	4	5	4	
B10	2	3	5	3	1	3	2	7	1	5	4	4	9	4	10	1	10	2	1	10	2	4	5	3	1	3	1	2	2	
B11	1	6	1	1	2	4	2	2	2	4	3	2	6	2	6	1	6	2	5	3		7	4	3	1	10	4	3	2	
B12	1	9	5	2	1	2		1		2	3		20	1	8	2	10	3	4	3	1	11			3	11	5	8	5	
B13		5	7	4	3	2	7	8	6	4	7	8	8	6	5	3	5	3	6	9	1	7	4	3	1	6	1	1	1	
B14	3	3	1	2	2	2	2	4	4	2	1	2	2	6	2	1	2	1	1	2	3	3	1	6	1	6	4	3	1	
B15	1	6	5	2	3	4	4	4	4	3	6	2	10		5	2	2	2	1	3	5	6	3	5	3	5	2	6	6	
B16	1	2	5	2	3	4		1	2	3	2	1	5		5	2	2	2	2	3	5	1	5	2	3	6	3	7	5	
B17	1	3	3	1	4	4	3	6	3	9	7	7	8	1	7	8	4	3	1	10	3	4	1	1	1	12	6	3	7	
B18		3	11	4	4	5	9	8	5	14	3	17	3		13		12	3	7	13		10	5	3	6	15	7	7		
B19	3	3	6	2	2	8	5	5	9	1	1	1	8	1	10	2	6	2	5	11		8	3	3	6	9	8	11	2	
B20		1	3	1	1	2	2	1	5	7		3	4	2	4		12	1	1	1		9				6	1		2	
Totals (2130)....	33	86	84	51	40	63	63	77	73	67	77	47	161	72	119	35	116	43	51	126	51	107	43	43	39	158	63	83	59	
Rank a.....	1	23	22	10	4	14	14	19.5	18	16	19.5	8	29	17	26	2	25	6	10	27	10	24	6	6	6	3	28	14	21	12
Rank b.....	1	13	12	4	2	5.5	5.5	10.5	9	7	10.5	3	14	8		1	12	4	6.5	13	6.5	11	4	4	4	2	14	9	10	8

TABLE 6
Maze BI. Number of trials per blind by individual subjects. Method II

SUBJECT	BLINDS IN SERIAL ORDER																													
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	
B1	15	4	15	3		7	12	10	13	15	5		13	8	7	3	7	3	10	6		7		7	2	14	8	8	5	
B2	3	10	6	4	3		5	20	12	20		5	17	16	2	9	9	2	14	17	15	11		2	5	20	4	2	5	
B3	5	3	2	4	2	2	7	11	2	3	3	3	19	13	11		19	8	10	11	11	2	8		3	8	2	3	5	
B4		9	8	6	2		3	2	2	3	2	2	5	7	10	2	8		5	9	6	7	3	5	8	10	5	8	10	
B5	8	6	8	4	4	4	2	4	12	4		9	4	8	3	4		5		7	7	3	4	5	3	4	5	5	12	
B6	3	3	7	5	4	4	7	3				4	7	2	6		10	5	10	6	6	8	8	5	9	9	3	9	4	
B7	2	14	13	5	8	8	11	3	14	14	10	11	10	8	7	4	11	4		3	9	8	3		2	15	9			
B8		11	12	8	9	9	18	20	24	11	18	10	23	24	17	17	18	11	19	23	23	18	8	20	5	20	11	18	12	
B9	11	19	12	5	3	8	11	5	19	4	9	4	18	21	20	4	8		8	13	10	17		9	4	12	7	7	7	
B10	3	5	10	7	3	5	8	16	13	22	15	5	20	19	11	4	19	5	9	15	12	13	13	13	2	8	6	7	6	
B11	3	8	2	2	3	5	3	13	12	9	5	5	10	12	16	7	12	10	12	14		12	6	4	2	17	10	11	4	
B12	3	23	10	3	3	4	2	0	5	8			25	6	13	4	14	7	17	4	2	16		5	15	15	15	15	15	
B13		14	11	5	5	8	13	12	9	15	13	13	15	15	9	13	10	7	16	16	4	12	6	9	9	16	3	2	2	
B14	5	6	3	3	3	3	5	5	5	3	2	3	8	6	3	3	4	2	8	6	6	7		2	7	7	5	5	6	
B15	4	8	8	4	4	7	8	8	8	9	3	12					3	3	5	8	9	12	10	3	6	9	8	10	10	
B16	2	5	10	3	4	5	3	3	3	5	3	2	6		6	4	5	3	8	8	5	9	9	3	4	9	5	12	6	
B17	2	7	5	2	5	7	5	13	12	14	14	16	13	17	13	12	10	4	15	16	15	10	4	9	12	15	13	11		
B18	9	14	19	5	5	7	13	13	16	11	20	17	21	19			20	6	22	22	21	13	8	8	18	15	17	19		
B19			5	9	3	10	9	7	12	2	3	2	13	9	12	4	11	7	16	16		9	10	9		10	11	14	16	
B20			2	9	2	4	5	2	16	15		10	6	9	7		16	2	3	3	14	10				12	2	8		
Totals (4525) ...	78	176	179	79	71	105	140	157	214	171	166	112	269	195	201	94	211	94	197	227	154	210	105	126	87	248	147	160	152	
Rank a.....	2	19	20	3	1	7.5	11	15	26	18	17	9	29	21	23	5.5	25	5.5	5.5	22	27	14	24	7.5	10	4	28	12	16	13
Rank b.....	2	10	11	3	1	4	6	7	13	9	8	5	14	12		2.5	12	2.5	10	13	8	11	4	5	1	14	6	9	7	

TABLE 7
Maze HI. Total number of subjects having trouble with each blind. Method III

BLINDS IN SERIAL ORDER																					
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
Totals (161)....	2	1	12	8	12	7	8	7	7	15	4	8	9	10	13	9	7	5	11	4	2
Rank a.....	2.5	1	18.5	12	18.5	8.5	12	8.5	8.5	21	4.5	12	14.5	16	20	14.5	8.5	6	17	4.5	2.5
Rank b.....	2	1	8.5	6.5	8.5	4	6.5	4	4	10		5	6.5	8	10	6.5	4	3	9	2	1

TABLE 8
Maze AI. Total number of subjects having trouble with each blind. Method III

BLINDS IN SERIAL ORDER																							
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46
Totals (201)	2	3	13	10	7	14	13	12	7	17	11	12	4	7	9	13	7	8	7	2	14	6	3
Rank a	1.5	3.5	19	14	9	21.5	19	16.5	9	23	15	16.5	5	9	13	19	9	12	9	1.5	21.5	6	3.5
Rank b	1	2	8.5	5	3.5	10	8.5	7	3.5	11	6		3	6	9	10	6	8	6	1	11	4	2

TABLE 9
Maze BI. Total number of subjects having trouble with each blind. Method III

		BLINDS IN SERIAL ORDER																											
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58
Totals (324).	5	14	16	107	12	12	10	10	12	11	11	7	18	9	17.5	15	7	9	16	8	16	9	9	8	19	11	14	9	
Rank a.....	1.5	21.5	25	14.4	19.5	14	14	19.5	17	17	4	28	10	27	1.5	23	4	10	25	6.5	25	10	10	6.5	29	17	21.5	10	
Rank b.....	1	12	13	62.5	10.5	6	6	10.5	8.5	8.5	2.5	14	4	1	11	2	6.5	12.5	3.5	12.5	6.5	6.5	3.5	14	9	10	6.5		

TABLE 10

Maze HI. Total number of forward-running errors per area by individual subjects

SUBJECTS	AREA 2-10	AREA 12-20	AREA 24-32	AREA 34-42
H1	10	14	15	4
H2	9	12	15	10
H3	10	14	16	5
H4	10	16	8	5
H5	10	22	15	7
H6	13	14	15	6
H7	19	10	27	17
H8	9	19	14	15
H9	15	14	17	4
H10	21	30	26	10
H11	26	19	29	19
H12	24	25	24	14
H13	13	20	25	29
H14	34	14	24	34
H15	21	28	29	33
Total.....	244	271	299	212

TABLE 11

Maze HI. Number of blinds per area giving trouble after the fifth trial

SUBJECTS	AREA 2-10	AREA 12-20	AREA 24-32	AREA 34-42
H1	1	2	3	1
H2	0	2	4	1
H3	1	3	2	0
H4	2	3	0	1
H5	1	3	4	0
H6	4	4	2	1
H7	2	1	5	2
H8	2	4	2	2
H9	3	4	3	1
H10	2	4	4	3
H11	4	5	5	3
H12	4	4	4	2
H13	1	3	5	5
H14	3	3	4	5
H15	3	4	5	3
Total.....	33	49	52	30

TABLE 12

Maze AI. Total number of forward-running errors per area by individual subjects

SUBJECTS	AREA 2-12	AREA 14-24	AREA 26-36	AREA 38-46
A1	22	37	17	14
A2	24	22	14	18
A3	16	18	8	10
A4	12	12	12	12
A5	16	21	12	4
A6	20	17	21	9
A7	7	16	10	4
A8	16	31	10	10
A9	25	46	23	25
A10	29	17	18	9
A11	13	23	18	20
A12	38	37	30	16
A13	20	18	8	6
A14	13	20	12	10
A15	35	31	27	12
A16	28	33	20	8
A17	26	37	20	10
A18	12	24	17	8
Total.....	372	460	297	205

TABLE 13

Maze AI. Number of blinds per area giving trouble

SUBJECTS	AFTER THE FIFTH TRIAL				AFTER THE TENTH TRIAL			
	Area 2-12	Area 14-24	Area 26-36	Area 38-46	Area 2-12	Area 14-24	Area 26-36	Area 38-46
A1	4	6	3	2	3	6	1	1
A2	4	4	2	1	1	1	0	0
A3	3	4	0	2	0	0	0	0
A4	1	1	3	2	0	0	0	0
A5	2	4	2	0	1	2	0	0
A6	2	4	4	3	0	1	1	0
A7	1	2	1	0	0	0	0	0
A8	4	5	3	3	0	2	0	0
A9	5	6	5	3	2	5	0	2
A10	3	4	4	1	2	3	3	1
A11	2	6	4	3	0	4	3	1
A12	6	5	6	3	5	5	6	1
A13	2	4	2	1	0	2	0	0
A14	1	3	3	2	0	3	2	0
A15	3	6	3	1	2	6	3	1
A16	4	5	4	1	3	4	2	0
A17	4	5	3	3	3	5	1	0
A18	2	5	4	2	0	4	0	0
Total.....	53	79	56	33	22	53	22	7

TABLE 14

Maze BI. Total number of forward-running errors per area by individual subjects

SUBJECTS	AREA 2-14	AREA 16-28	AREA 30-42	AREA 44-58
B1	12	23	16	24
B2	23	33	26	26
B3	15	29	25	17
B4	16	11	17	26
B5	21	19	16	20
B6	21	11	16	26
B7	29	31	20	16
B8	25	62	65	55
B9	29	35	35	29
B10	19	34	36	20
B11	17	21	23	34
B12	20	27	31	43
B13	28	47	32	23
B14	15	18	8	18
B15	23	25	15	36
B16	17	11	20	32
B17	15	41	36	28
B18	39	48	48	60
B19	26	26	36	44
B20	10	22	20	18
Total.....	420	574	541	595

TABLE 15

Maze BI. Number of blinds per area giving trouble

SUBJECTS	AFTER THE FIFTH TRIAL				AFTER THE TENTH TRIAL			
	Area 2-14	Area 16-28	Area 30-42	Area 44-58	Area 2-14	Area 16-28	Area 30-42	Area 44-58
B1	1	5	4	5	2	3	1	1
B2	3	5	5	2	1	5	3	1
B3	1	3	6	3	0	2	1	0
B4	2	1	3	5	0	0	0	0
B5	2	3	3	1	0	1	0	1
B6	2	1	2	4	0	0	0	0
B7	5	6	3	3	2	2	0	1
B8	6	7	7	7	2	5	6	5
B9	5	4	5	6	2	3	2	2
B10	3	6	5	5	0	6	3	3
B11	1	5	6	4	0	3	4	2
B12	2	2	4	5	1	1	3	5
B13	4	7	6	4	2	6	3	2
B14	0	1	1	2	0	0	0	0
B15	4	4	2	7	0	1	0	1
B16	1	0	2	4	0	0	0	1
B17	1	6	6	6	0	7	5	3
B18	5	6	4	8	3	5	4	6
B19	3	4	5	6	0	2	3	1
B20	1	4	3	3	0	2	2	1
Total.....	52	80	82	90	15	54	40	36

	8	659	7h 87%	1,414	7h 87%	94		7h 87%	40 44 46	19 38 24	1.5 7.5 4	63 92 97	3 6 7	2 6 3	1.5 6 3.5
BI	4	86	23	176	19	14	21.5	24	47	8	8L 66%	112	9	7	4
	6	84	22	179	20	16	25	28	72	17		195	21	9	10
	12	63	14	105	7.5	12	19.5	32	35	2		94	5.5	5	1.5
	14	63	14	140	11	10	14	46	43	6		105	7.5	9	10
	16	77	19.5	157	15	10	14	48	43	6		126	10	9	10
	18	73	18	214	26	12	19.5								
	20	67	16	171	18	11	17								
	26	161	29	269	29	18	28								
	30	119	26	201	23	17	27								
	36	43	6	94	5.5	7	4								
	40	126	27	227	27	16	25								
	52	158	28	248	28	19	29								
	56	83	21	160	16	14	21.5								
	58	59	12	152	13	9	10								
Totals.....	14	1,194	10h 71%	2,446	10h 71%	176	10h 71%	5	475	4L 80%		1,044	4L 80%	71	5L 100%
	30	2,436	25h 83.3%	5,054	24h 80%	355	23h 76%	28	1,352	21L 75%		3,359	21L 75%	208	22L 78%

TABLE 16—Continued

MAZE	DIRECTION—SAME AS NEXT CORRECT TURN						DIRECTION—OPPOSITE FROM NEXT CORRECT TURN					
	Blind	Method I		Method II		Method III	Blind	Method I		Method II		Method III
		Totals	Rank	Totals	Rank			Totals	Rank	Totals	Rank	
HI	6	71	17	143	13	12	4	9	1	29	1	1
	8	55	14	110	9	8	22	24	4	64	4	4.5
	10	87	19	153	15	12	24	48	11.5	158	18	12
	12	48	11.5	147	14	7	26	57	15	168	20	14.5
	20	95	21	187	21	15	42	16	2	54	2	2.5
AI	30	91	20	155	17	13						
	38	82	18	166	19	11						
	7	529	7h 100%	1,061	6h 85%	78	5	154	3L 60%	473	3L 60%	24 3L 60%
	6	69	16	148	11	13	4	19	1.5	50	1	3.5
	8	64	14	157	12	10	22	55	10	184	16	15
BI	10	114	22	188	17.5	7	26	22	3	64	4	5
	12	79	19	200	21	14	28	38	7.5	122	9	7
	20	122	23	225	23	17	38	29	6	67	5	9
	34	40	9	113	8	7	40	19	1.5	63	3	1.5
	44	38	7.5	92	6	6	46	24	4	97	7	3.5
BI	7	526	5h 71%	1,123	5h 71%	74						
							7	206	6L 85%	647	6L 85%	37 6L 85%
	2	33	1	78	2	5	14	63	14	140	11	14
	4	86	23	176	19	14	24	47	8	112	9	4
	12	63	14	105	7.5	12	48	43	6	126	10	10
BI	26	161	29	269	29	18	50	39	3	67	4	6.5

	28	72	17	195	21	9	10												
	34	116	25	211	25	15	23												
	52	158	28	248	28	19	29												
	56	83	21	160	16	14.	21.5												
	58	59	12	152	13	9	10												
	9	882	6h 66%	1,748	6h 66%	123	6h 66%	4	192	4L 100%	465	4L 100%	34	4L 100%	465	4L 100%	34	4L 100%	
Totals.....	23	1,937	18h 78%	3,932	17h 73%	275	16h 69%	16	552	13L 81%	1,585	13L 81%	95	13L 81%	1,585	13L 81%	95	13L 81%	

Totals, method I, indicates total number of entrances per blind for each maze.

Totals, method II, indicates total number of trials per blind for each maze.

Totals, method III, indicates total number of subjects having trouble per blind for each maze.

h indicates high rank. L indicates low rank.

TABLE 17
Maze HI. Backward-running errors
Type I

BLINDS IN SERIAL ORDER																			
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38
T.	42	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6
Totals...	2	2	6	5	15	2	3	4	4	10	0	0	2	0	2	3	0	6	1
Rank a..	8.5	8.5	18.5	17	21	8.5	12.5	15	15	20	2.5	2.5	8.5	2.5	8.5	12.5	2.5	18.5	5
Rank b..	2	2	8	7	10	2	4	5.5	5.5	9			2	2	6	8	2	10	4
T.	73	2	6	7	10	2	4	5.5	5.5	9			2	2	6	8	2	10	4

Type II

CORRECT ALLEYS IN SERIAL ORDER																			
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37
T.	43	41	39	37	35	33	31	29	27	25	23	21	19	17	15	13	11	9	7
Totals...	0	1	3	3	3	4	11	2	3	3	2	4	5	7	6	3	2	10	2
Rank a..	2	4	12.5	12.5	12.5	16.5	22	7	12.5	12.5	7	16.5	18	20	19	12.5	7	21	7
Rank b..	1	2	7	7	7	10	11	3.5	7	7	3.5	7	8	10	9	6	4	11	4
T.	76	2	0	2	7	2	0	2	4	1.5	4	1.5	4	1.5	4	1.5	4	1.5	4

Type I, total number of errors for all subjects, 73. Type II, total number of errors, 76.
Totals, total number per blind for all subjects.
Rank a, ranks for whole maze arranged in ascending order of difficulty.
Rank b, ranks within halves of the maze.

TABLE 18
Maze A1. Backward-running errors
Type I

		BLINDS IN SERIAL ORDER																							T.	
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46		
Totals...	1	2	0	4	17	1	5	3	6	12	7	3	1	0	0	7	0	4	2	0	3	1	2	81		
Rank a..	7.5	11	3	16.5	23	7.5	18	14	19	22	20.5	14	7.5	3	3	20.5	3	16.5	11	3	14	7.5	11			
Rank b..	2.5	4	1	6	11	2.5	7	5	8	10	9		5.5	2.5	2.5	11	2.5	10	7.5	2.5	9	5.5	7.5			

Type II

		CORRECT ALLEYS IN SERIAL ORDER																							T.	
		1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	
Totals...	0	0	3	0	6	0	0	4	1	0	0	0	1	1	0	1	0	1	3	4	1	0	1	1	1	
Rank a..	5.5	5.5	20.5	5.5	24	5.5	22.5	15	5.5	5.5	5.5	5.5	15	15	5.5	15	5.5	15	20.5	22.5	15	5.5	15	15	15	
Rank b..	4	4	10	4	12	4	11	8.5	4	4	4	4	8.5	7	2	7	2	7	11	12	7	2	7	7	7	

TABLE 19
Maze BI. Backward-running errors
Type I

BLINDS IN SERIAL ORDER																														
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	T.
Totals...	0	18	7	102	3	0	9	3	3	4	2	16	4	18	8	2	4	7	150	3	6	3	3	3	240	6	1	181		
Rank a...	2.57	520.5	247	11.5	2.5	23	11.5	11.5	16	7	26	16	27.5	22	7	16	20.5	25.2	51.5	18.5	11.5	11.5	29.2	5	18.5	5				
Rank b...	1.514	10	123.5	6	1.5	11	6	6	8.5	3.5	13	8.5	12	4	8	11	131.5	6	9.5	6	6	6	14.1	5	9.5	3				

76

Type II

CORRECT ALLEYS IN SERIAL ORDER																																
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	T.	
Totals...	0	3	2	3	3	0	6	1	2	6	3	4	1	0	2	1	2	4	1	3	7	2	7	11	2	2	0	1	181			
Rank a.	2	5	21	15	21	2	26	58	15	26	521	24	58	2	5	8	15	24	5	8	21	28	5	28	5	830	15	2	5	8	8	
Rank b.	2	10	5	7	10	5	2	14	5	7	14	5	10	5	13	4	8	5	12	4	11	13	5	8	5	4	15	8	5	1	4	4

TABLE 20
Maze BII. Number of entrances per blind by individual subjects. Method I

SUBJECTS	BLINDS IN SERIAL ORDER															
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32
B1									1	1		2	4		2	
B2									1	1		3	1		2	
B3								1	2	2					1	
B4							1	1	2	2	4	3	4		2	
B5	2								2	2		5	4		4	
B6							2		3	3	1	2			1	
B7									3	4	4	2			1	
B8									3	1		2			2	
B9									1	1		1			1	
B10									1	1		1			1	
B11									1	2		2	1		1	
B12									1	4		3			3	
B13									3	1	2	2			2	
B14									1	1	1	1			1	
B15									1	1		2			2	
B16									2	2		2	1		2	
B17									1	1		1	1		2	
B18									2	2		2			1	
B19									1	1	3	2			1	
B20							1			3		1	2		2	
Totals (198) ..	0	2	0	0	0	0	4	2	13	37	16	39	190	34	16	
Rank a.....	5.5	13.5	5.5	5.5	5.5	5.5	18	13.5	20	25	21.5	26	23.5	5	21.5	
Rank b.....	6.5	3	3	3	3	3	8	6.5	9	12	10	13	11.3	13	12	

TABLE 22
Maze BIII. Number of entrances per blind by individual subjects. Method I

SUBJECTS	BLINDS IN SERIAL ORDER																			
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
B1																				
B2																				
B3																				
B4																				
B5																				
B6																				
B7																				
B8																				
B9																				
B10																				
B11																				
B12																				
B13																				
B14																				
B15																				
B16																				
B17																				
B18																				
B19																				
B20																				
Totals (163)...	0	0	0	0	0	0	0	0	0	1	1	6	2	0	3	3	0	28	31	8
Rank a.....	6	6	6	6	6	6	6	6	6	12.5	12.5	17.5	14	6	15.5	15.5	6	23	24	19
Rank b.....	5	5	5	5	5	5	5	5	5	10.5	10.5	12		1.5	3.5	3.5	1.5	10	11	6

TABLE 23
Maze BIII. Number of trials per blind by individual subjects. Method II

SUBJECTS	BLINDS IN SERIAL ORDER																								
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
B1																		3	4		2	2			4
B2															3	3		2	4		2	2			4
B3																4		2	2						3
B4																		2	2		2	2			4
B5																		2	2						3
B6																		2	4		2	2			2
B7																		2	3						3
B8															7			3	4		4	2			7
B9																		2	2						2
B10																		2	4		3	5			5
B11																		2	2		4	2			2
B12																		5	4		3	3			7
B13																		2	2						3
B14																		2	2						2
B15																		2	2		2	2			4
B16																		3	3						3
B17																		2	2		2	2			2
B18										2								4	5		2	2			2
B19																		2	2						2
B20																		2	2						2
Totals (353)...	0	0	0	0	0	0	0	0	0	2	4	16	6	0	10	7	0	48	54	24	23	37	11	49	62
Rank a.....	6	6	6	6	6	6	6	6	6	12	13	18	14	6	16	15	6	22	24	20	19	21	17	23	25
Tank b.....	5	5	5	5	5	5	5	5	5	10	11	12		1.5	4	3	1.5	9	11	7	6	8	5	10	12

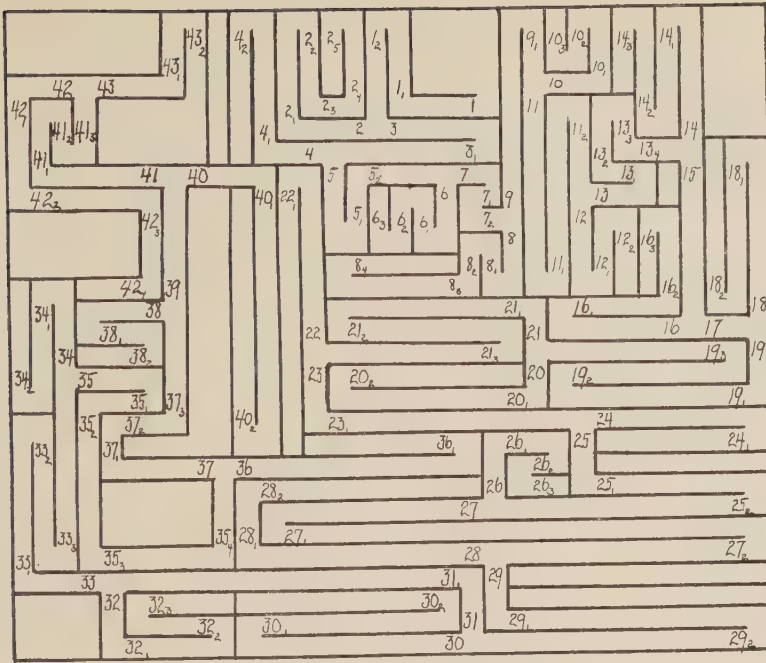


FIG. 1. MAZE HI

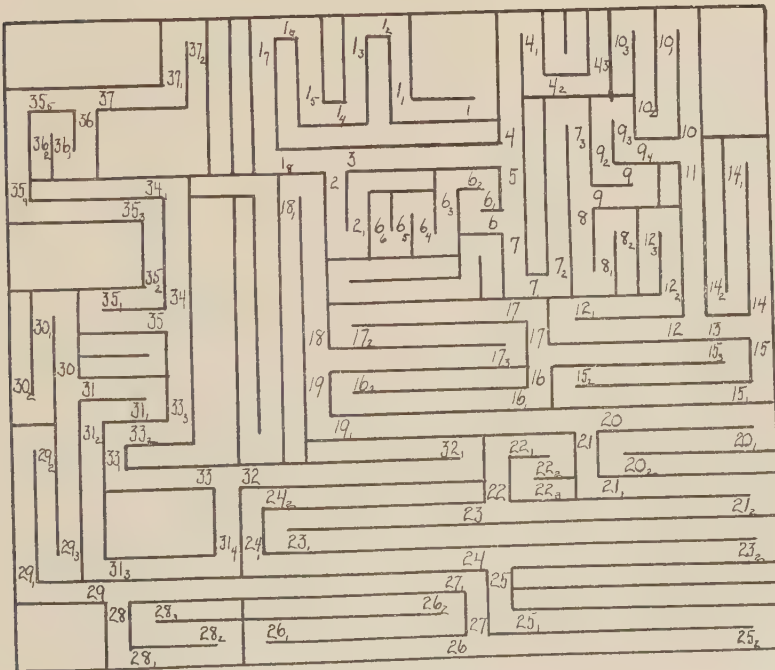


FIG. 2. MAZE HII

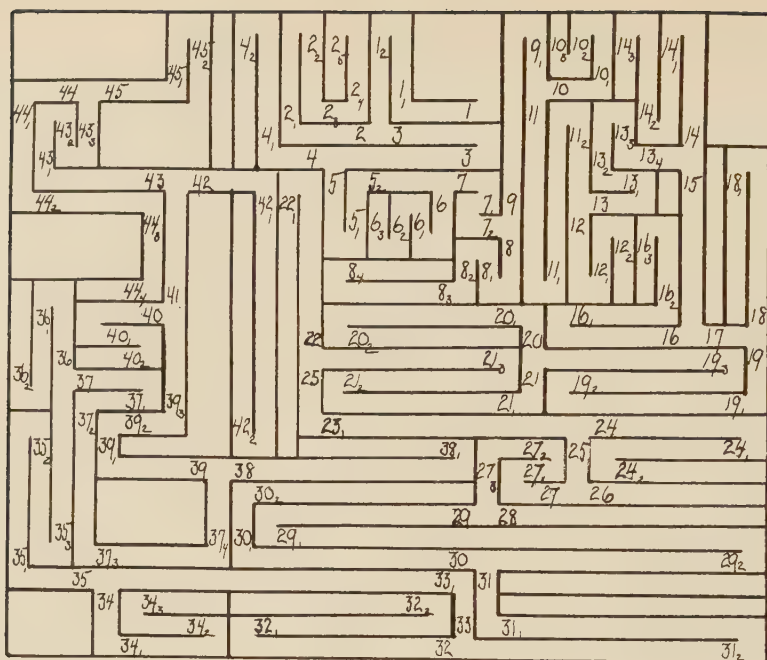


FIG. 3. MAZE HIII

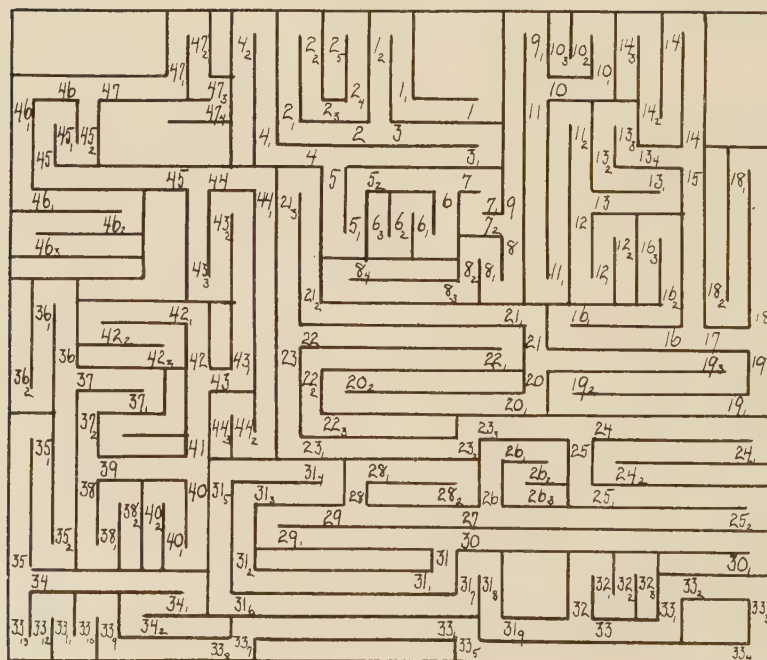


FIG. 4. MAZE AI

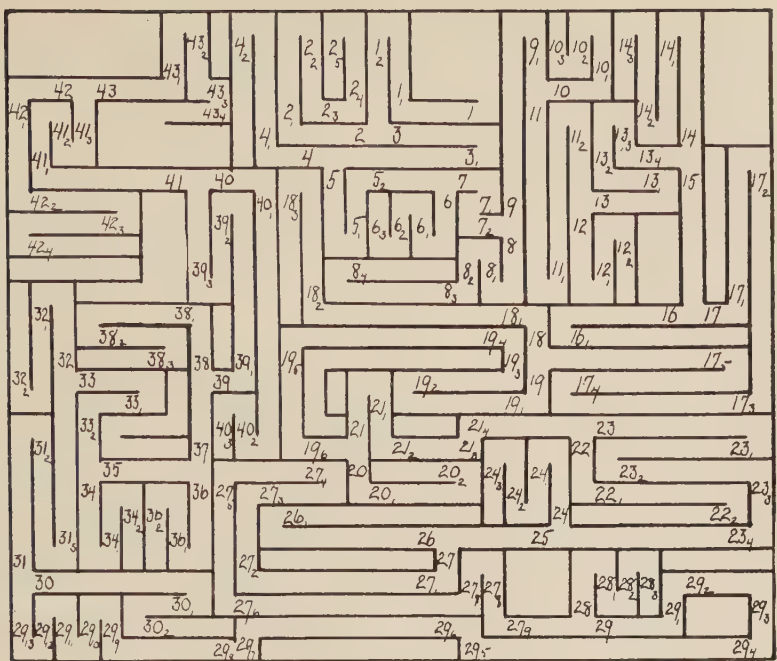


FIG. 5. MAZE AII

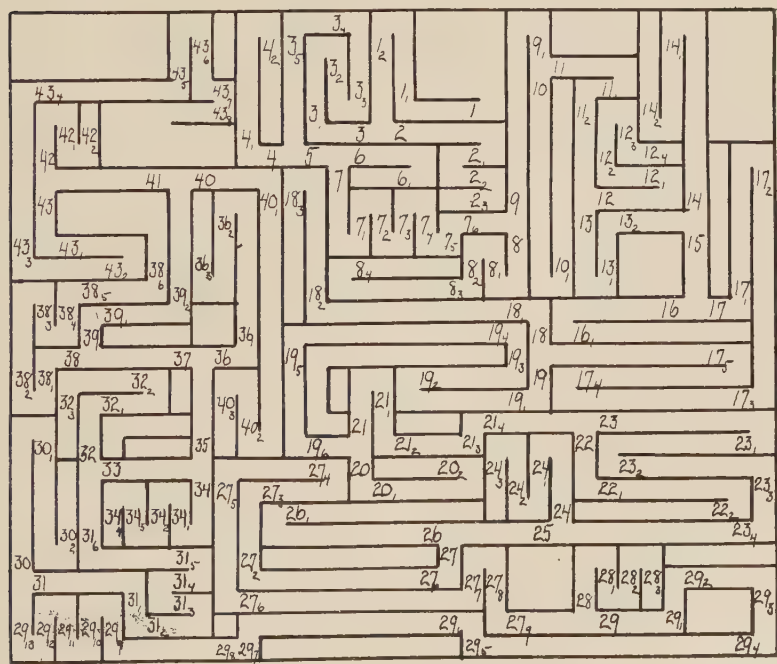


FIG. 6. MAZE AIII

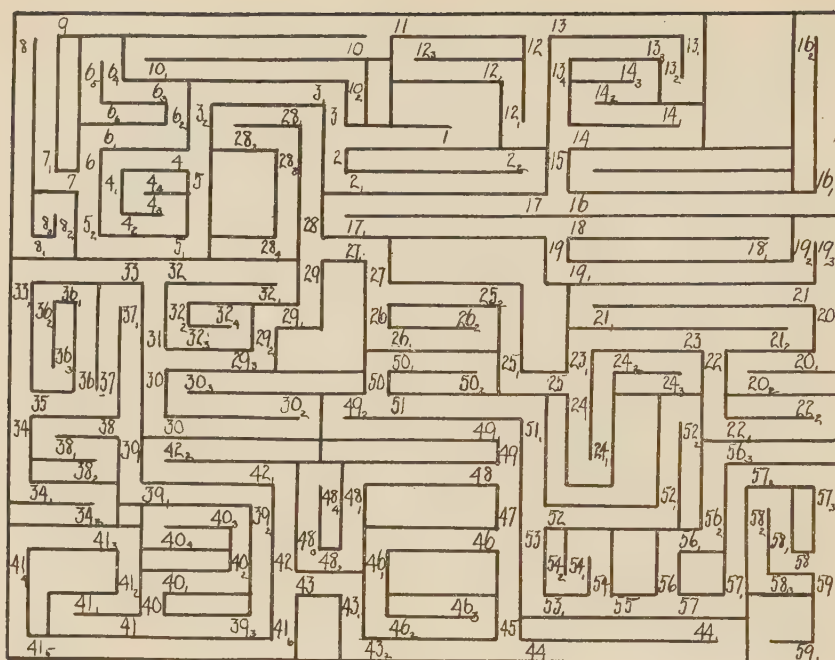


FIG. 7. MAZE BI

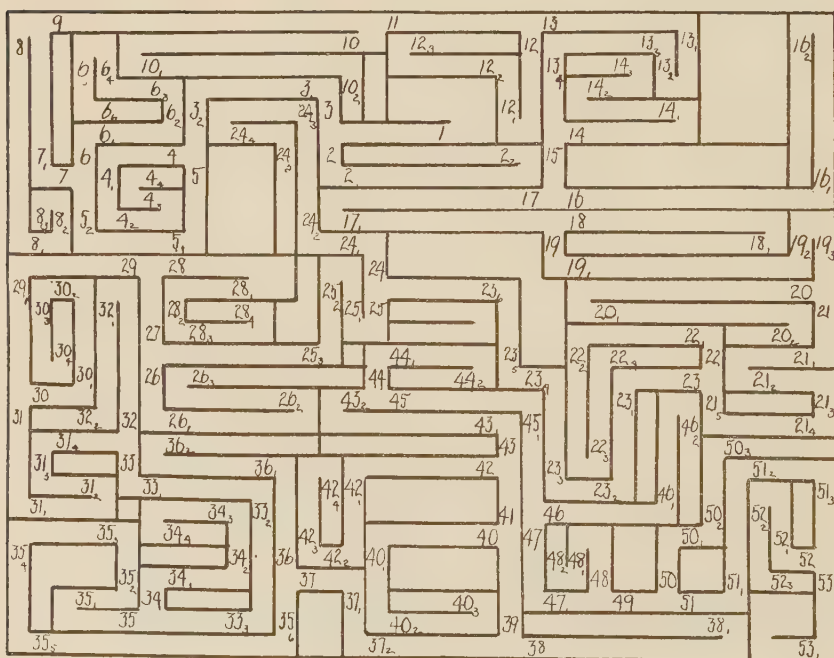


FIG. 8. MAZE BII

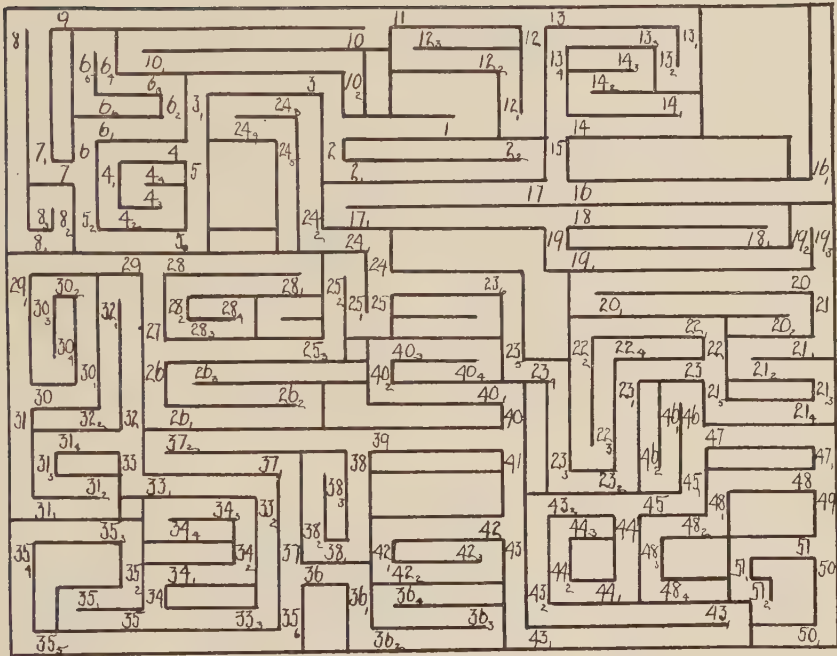


FIG. 9. MAZE BIII

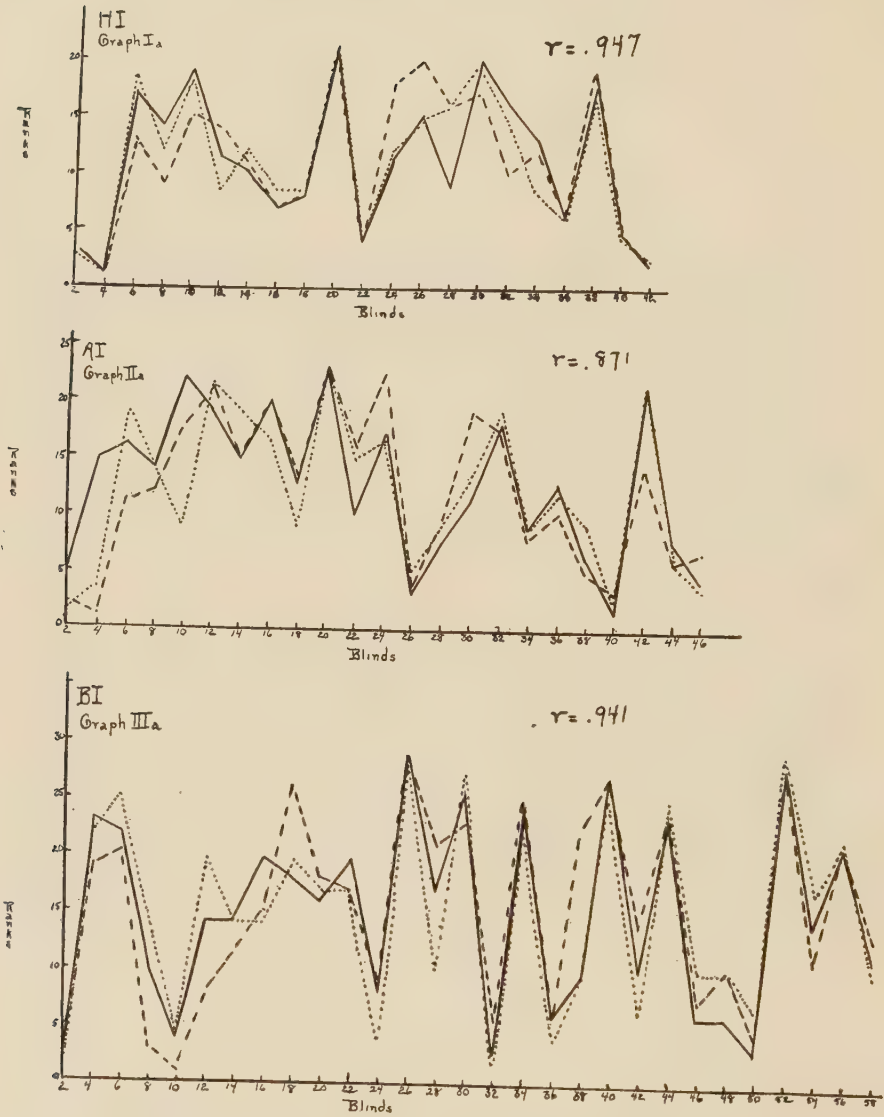


FIG. 10. ANALYSIS OF FORWARD RUNNING ERRORS

———— Method I. Total number of entrances per blind by individual subjects.

----- Method II. Total number of trials per blind by individual subjects.

..... Method III. Total number of subjects having trouble with each blind.

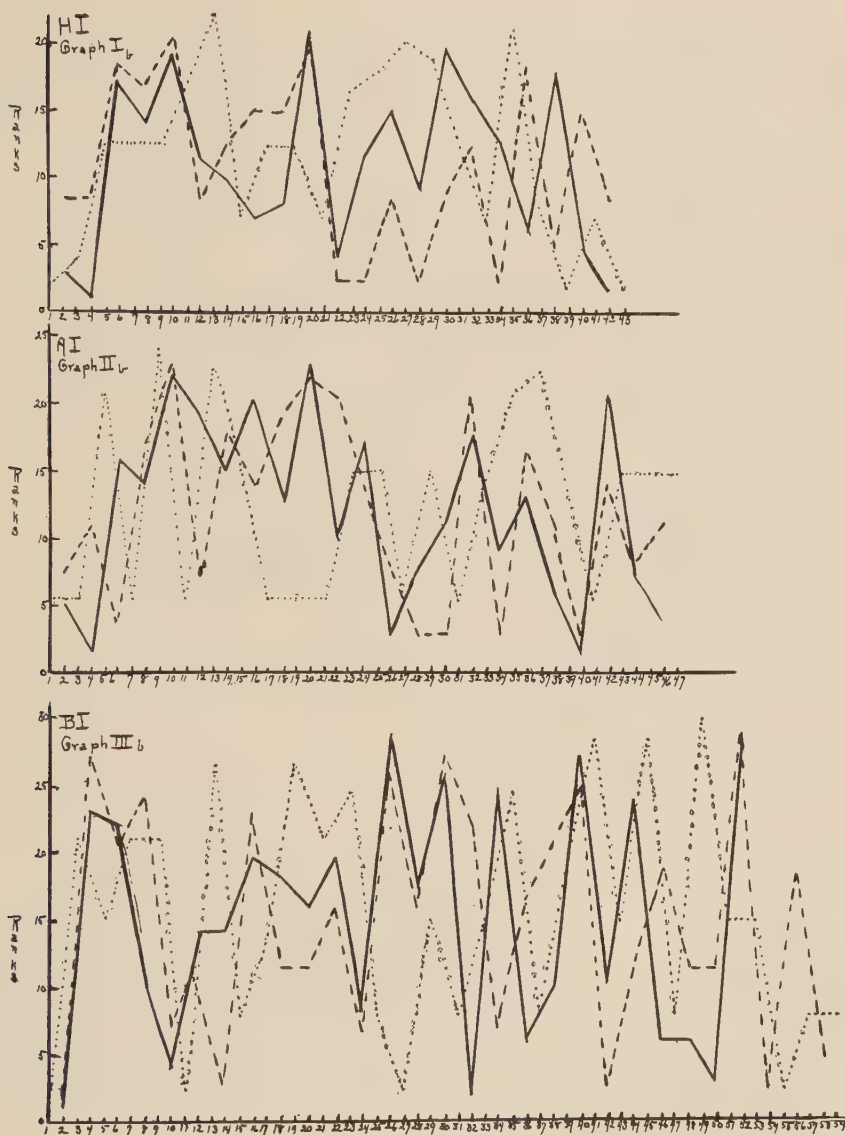


FIG. 11. ANALYSIS OF BACKWARD RUNNING ERRORS

———— Method I (forward running). Total number of entrances per blind by individual subjects.

----- Type I. Faulty emerging from a blind.

..... Type II. Return on true path into a blind.

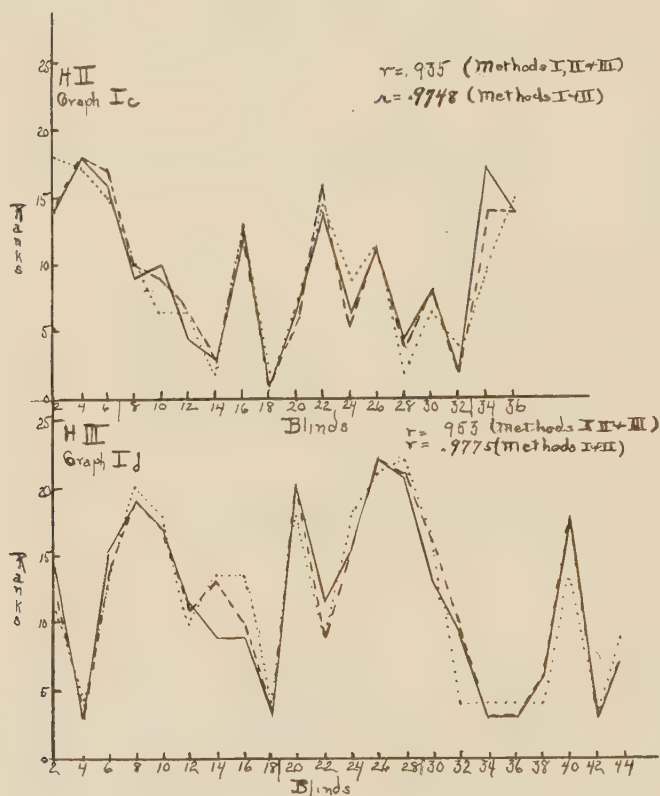


FIG. 12. ADAPTING TO CHANGES

———— Method I. Total number of entrances per blind by individual subjects.

----- Method II. Total number of trials per blind by individual subjects.

..... Method III. Total number of subjects having trouble with each blind.

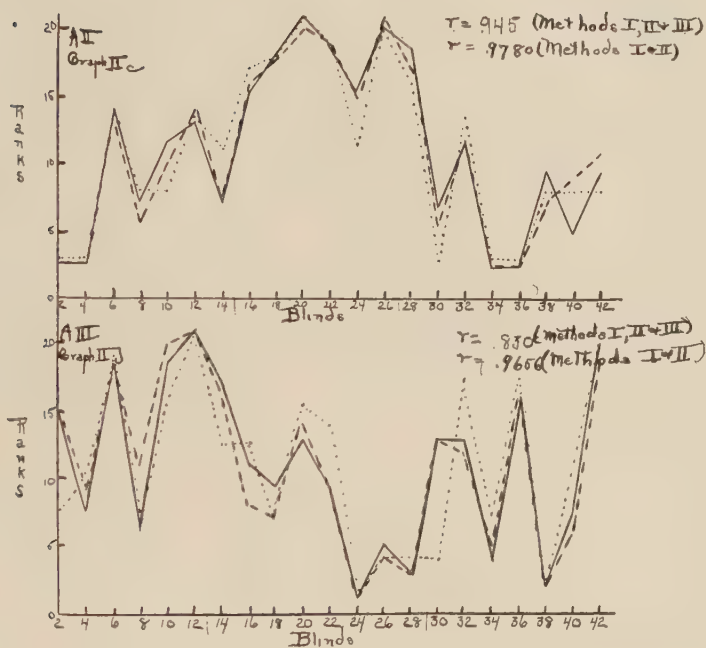


FIG. 13. ADAPTING TO CHANGES

——— Method I. Total number of entrances per blind by individual subjects.

----- Method II. Total number of trials per blind by individual subjects.

..... Method III. Total number of subjects having trouble with each blind.

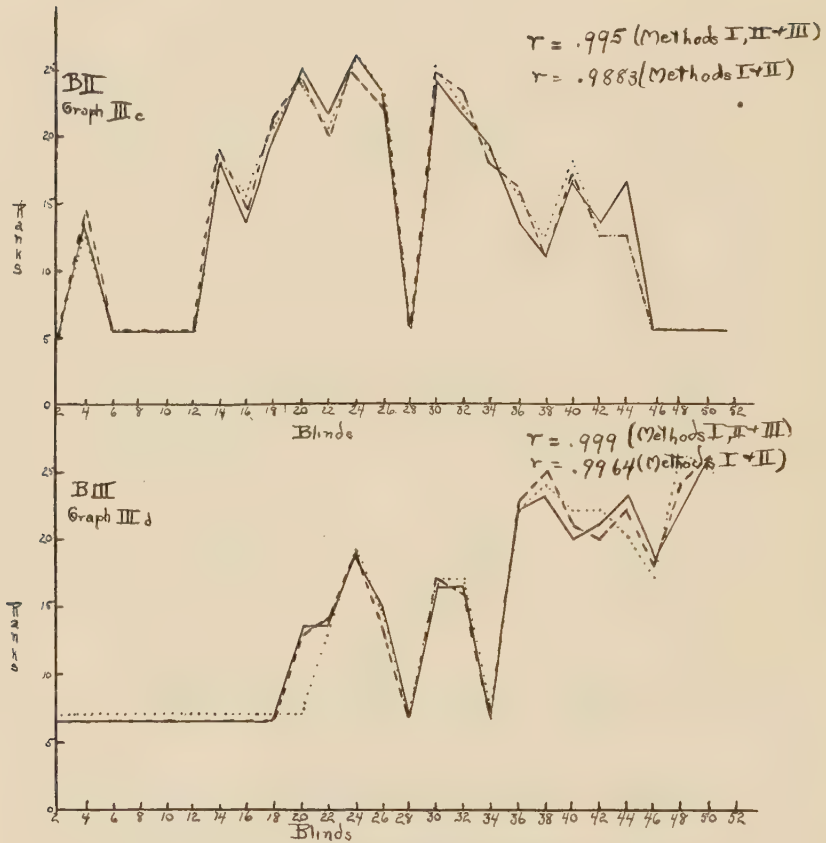


FIG. 14. ADAPTING TO CHANGES

- Method I. Total number of entrances per blind by individual subjects.
- Method II. Total number of trials per blind by individual subjects.
- Method III. Total number of subjects having trouble with each blind.

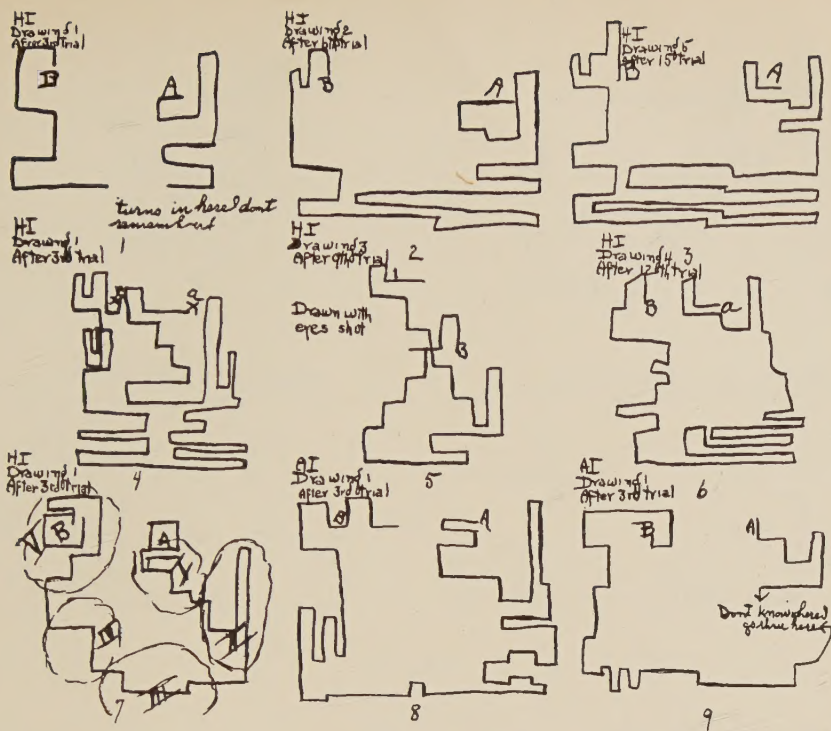


FIG. 15

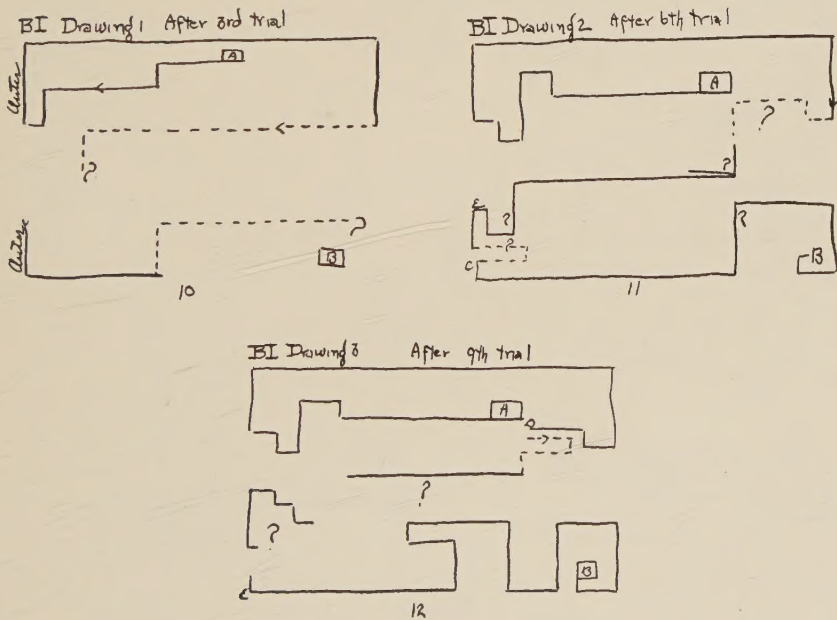


FIG. 16

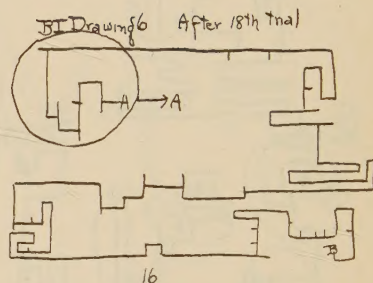
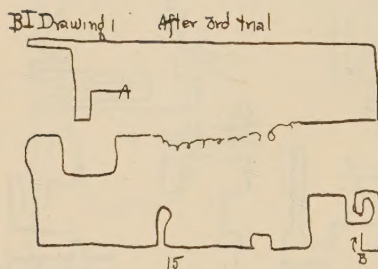
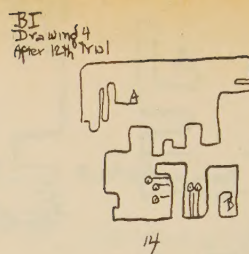
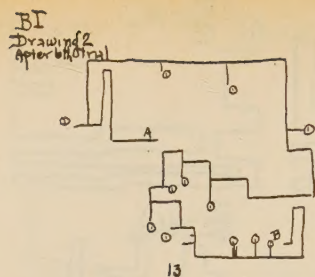
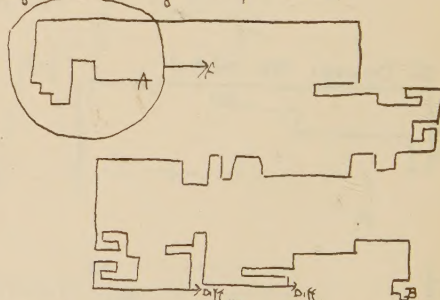
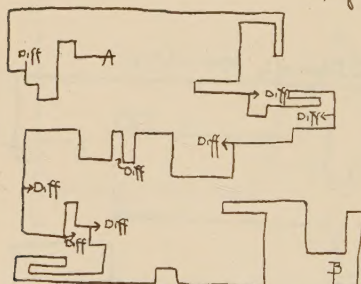


FIG. 17

BII Drawing 1
After 3rd Trial

~~Figure 18~~
Adapting to Changes BIII Drawing 1
After 3rd Trial



HII Drawing 1
After 3rd Trial

HIII Drawing 1
After 3rd Trial

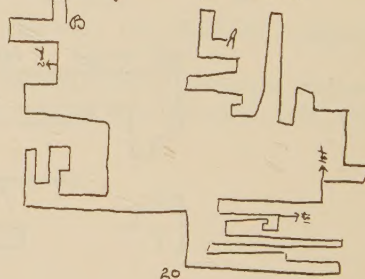
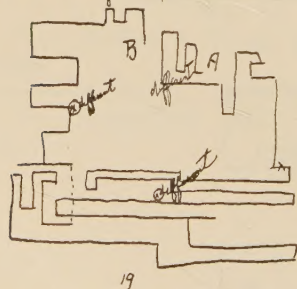


FIG. 18

